Hydrology of Agate Fossil Beds National Monument Nebraska

Technical Report NPS/NRWRD/NRTR-2005/327

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February 2005

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National Monument

Nebraska

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Executive Summary

Agate Fossil Beds National Monument is in central Sioux County, in northwestern Nebraska, on the western edge of the Sand Hills. Water resources at Agate Fossil Beds are dominated by the Niobrara River, which flows from west to east through the middle of the park.

Surface water diversions from the Niobrara River and groundwater pumping provide water for irrigation and municipal use upstream of the park in Nebraska and Wyoming. Locations of surface water diversions and irrigation wells are shown on maps and estimates of irrigated acreage along the Niobrara River upstream of the park are tabulated and summarized.

Streamflow in the Niobrara River has been gaged at the upstream (west) side of the park since 1957. The gaging station has been operated by the USGS, NPS, and Nebraska DNR. Previously unpublished streamflow data for the period when NPS personnel operated the streamflow gage (1995-2004) are included in the appendices.

Water for potable use, irrigation, and fire protection at the park is obtained from wells. Annual usage for all facilities at the park is about 2,500,000 gallons, or 7.7 acre-feet.

Most of the water quality data that are available for the park are associated with the Long Term Ecological Monitoring (LTEM) macroinvertebrate monitoring program and are from sampling locations near the streamflow gaging station at the Highway 29 bridge on the west side of the park. The NPS Northern Great Plains Network is developing a new monitoring plan for aquatic ecosystems at the park.

Previous geologic and hydrologic reports, letters, and memos are included in the appendices of this report.

Hydrology of Agate Fossil Beds National Monument, Nebraska

Physical Setting

Agate Fossil Beds National Monument is in central Sioux County, in northwestern Nebraska, on the western edge of the Sand Hills (Figure 1). The park is in the Niobrara River Valley about 40 miles north of Scottsbluff. The park preserves a unique unglaciated area of the High Plains. Wetlands stretch out from the river and meet terraces that lead to breaks and buttes. The buttes contain fossil remains, providing important information about the life of mammals in the Miocene Era, 19-22 million years ago.

Agate Fossil Beds National Monument is a small park unit with only 2,700 acres of federally managed land included in the 3050 acres within the park boundary (Figure 2). Once part of "Captain" James H. Cook's Agate Springs Ranch, the nearby beds are an important source for Miocene epoch mammal fossils. Cook's ranch was also a gathering place for Chief Red Cloud and other Oglala Lakota (Sioux) Indian people.

Water resources at Agate Fossil Beds are dominated by the Niobrara River, which flows from west to east through the middle of the park. Groundwater in the alluvium adjacent to the river is closely interconnected with surface water in the river. The alluvium is a buffer to streamflow, accepting recharge during periods of high streamflow and slowly releasing the water from storage during periods of low streamflow.

Water Use in Wyoming and Interstate Compact

The Niobrara River has its headwaters in eastern Wyoming. The river drains about 450 square miles in Wyoming, mostly in southeastern Niobrara County around the Lusk area. The Upper Niobrara River Compact was signed by Nebraska and Wyoming in 1962. This agreement placed limitations on reservoir construction and direct use of surface water for irrigation in Wyoming. Ground water development is recognized to be a significant factor of the hydrologic regime and the compact provides for investigation of this resource and possible apportionment at a later date. No apportionment of groundwater has yet occurred under this compact.

Water use in the Niobrara River Basin in Wyoming includes irrigation of 15,000 acres from groundwater sources and 1000 acres from surface water sources, consuming about 16,000 acre-feet/year. Municipal use in the communities of Manville, Lusk, and Van Tassel consumes about 120 million gallons per year (370 acre-feet) (HKM Engineering, et.al., 2002).

Streamflow Gage at Wyoming-Nebraska Border

A streamflow gage has been operated on the Niobrara River near the Wyoming-Nebraska border since 1955. The USGS operated the gage until October 1, 1994. Records for the period from 1955-94 are available from the USGS databases. Nebraska DNR took over operation of the station in October 1994. Shortly thereafter the measuring point was moved downstream 0.4 mile, 0.1 mile downstream of the Wyoming-Nebraska State Line. Streamflow records after October 1, 1994 are available from Nebraska DNR and are published in DNR's annual Hydrographic Report.

Water Use Between the Wyoming-Nebraska Border and the Park

Records for diversion of surface water from the Niobrara River were obtained by searching the Nebraska DNR website *(http://www.nrc.state.ne.us/docs/surface.html)*. There are 11 water rights for diversion of from the Niobrara River between the Wyoming-Nebraska border and Agate Fossil Beds (Table 1). These rights allow diversion of water to irrigate 1900 acres.

The Harris-Neece Canal diverts water from the river immediately downstream of the park. This ditch is permitted for diversion of water to irrigate 676 acres.

Locations of surface water diversions are shown on the map in Figure 3. The amount of water diverted annually for each ditch is reported in DNR's annual Hydrographic Report. Diversions from the Niobrara River for 1995-2003 are shown in Table 2.

These data do not account for return flow or groundwater discharge to the river. As the river flows downstream, groundwater discharge to the river increases flow. Otherwise, simple math would show that there is not enough flow crossing the state border to provide the amount of water diverted above, and immediately below, the Park.

The Nebraska DNR website *(http://www.nrc.state.ne.us/docs/groundwat.html)* was searched to identify irrigation wells within about 1 mile of the Niobrara River. This distance was chosen as the probable maximum distance that an irrigation well might have an influence on flow in the river. A total of 16 wells were identified upstream of the park (Table 3 and Figure 4). These wells are permitted to irrigate a total of 1600 acres. Immediately downstream of the park, two more irrigation wells are permitted for irrigation of 260 acres.

Streamflow Gage at Agate

The USGS operated a streamflow gaging station on the Niobrara River just upstream of the Highway 29 bridge from 1957-91 (Station Number 06454100). Park staff have continued to operate the chart recorder at the site since 1991. The record since 1991 is not continuous because there were many times when the recorder was not functioning properly. Hydrographs showing the streamflow for the periods when the recorder was functioning properly are shown in Figure 5. Annual hydrographs showing more detail for each year are included in the appendices of this report.

In 2002-03, USGS personnel made several streamflow discharge measurements to check the validity of the rating curve for the site. Data collected in 2002-03 are shown on Figure 6 along with the rating curve that was used prior to 1991. The data from 2003-03 show that the rating curve is still a fairly reliable tool for converting stage (water level) in the stream to flow rates.

In fall of 2004, Nebraska DNR staff installed a datalogger and began operation of a streamflow gaging station at the site. The datalogger was purchased by NPS. Nebraska DNR staff will make regular measurements of streamflow, collect and analyze data, and publish the mean daily streamflow at the site in DNR's annual Hydrographic Report.

Water Use at Agate Fossil Beds

The location of water supply wells at the park is shown on Figure 7.

Prior to 2005, potable water for visitors to the park was provided from a 240-foot deep well located north of the main road, across from the Visitor Center and Museum. The well was tested at a rate of 160 gpm for 30 hours at the time of construction (1967). The water was of good quality and was chlorinated as a standard precaution. Water for four park staff houses in the eastern housing area and the maintenance shop was provided from a 180-foot deep well near the maintenance shop. Water was pumped to pressure tanks in the maintenance shop and then sent out through the distribution system.

In the winter of 2004-05, the water system was rehabilitated and upgraded to create a safer, more efficient system that is not susceptible to disruptions from power outages. The new system utilizes the domestic supply well in the maintenance area as the primary source. A new water line was constructed from the well to the storage tank. The distribution system from the storage tank was expanded to interconnect all facilities at the Visitor Center and Museum, the eastern housing area, and the maintenance shop. This system also provides irrigation water for lawns. The fire supply well provides the backup supply. The

old visitor center well (Figure 7) was maintained as a monitoring well, but the well house and all the associated equipment were removed.

Water for fire suppression is provided from a large volume well (300 gpm) near the maintenance shop.

Water for the Hoffman House (staff housing on the south side of the river) is provided from a well next to the house. This well was repaired in 2003. A new pump and drop pipe were installed, which eliminated problems of rusty water that had occurred in the past. The well was test pumped at 50 gpm with no measurable drawdown. The water is hard but otherwise of good quality.

Average daily water use at the Visitor Center and Museum was computed from records of pumping from the well near the visitor center. These data do not include water usage at the maintenance shop or the employee residence area. Average daily water usage ranges from a few hundred gallons per day in the winter to about 10,000 gallons per day in the summer (Figure 8). The increase in water usage in the summer of 2001 was caused by irrigation of newly planted lawns near the new visitor center during an exceptionally hot, dry summer.

Water usage for the maintenance and eastern housing area averages 900,000 gallons per year during normal years (1996-2000) and about 1,750,000 gallons during dry years (2002-2004). Annual usage for all facilities at the park is about 2,500,000 gallons, or 7.7 acre-feet (AGFO, 2004).

Water Use Immediately Downstream of the Park

Immediately downstream from the park, the Skavdahl Brothers farming operation uses both surface and groundwater for irrigation. The headgate for the Harris-Neece Ditch on the Niobrara River is within the Skavdahl Brothers' inholding, just downstream from the park fee lands. This ditch is permitted for diversion of 9.67 cfs to irrigate 676 acres. From 1995-2003, diversions have ranged from about 1500-2000 acre-feet/year. There are also two irrigation wells to provide supplemental water for irrigation. One of these wells is on the east side of the fence marking the eastern boundary of park fee lands, near the eastern housing area. The other well is further east on the north side of the River Road.

Regular monitoring of water levels in the park's domestic supply well near the maintenance shop will show whether pumping at the nearby irrigation well has a significant effect on the water table in the area. However, it will be difficult to separate water table drawdown from pumping at the irrigation well from effects caused by pumping from the park's water supply well. Previous investigations of the hydrogeology of the area (Bradley, 1956 and Emery, 1966) have shown that there is plentiful groundwater in the area and it is unlikely that the amount of

groundwater pumped from the park wells and the two adjacent irrigation wells will have a significant effect on the hydrology of the area.

Water Quality

An inventory and analysis of water-quality data revealed a shortage of surface-water chemistry data in the study area and a clustering of stations (NPS, 1998). Five of seven water quality monitoring stations were located in the area of the State Highway 29 Bridge near the west side of the park, including one station that accounted for 77% of the 1270 total observations. The station with the majority of the water quality data was operated by the Nebraska Department of Health from 1968-93. None of the seven stations was located outside the park boundary. Without adequate data it is difficult to make definitive statements regarding surface water quality within the study area; however, from the limited available data, water quality generally appears good. Potential contamination sources are mostly limited to agricultural products: pesticides, herbicides, fertilizer, and byproducts contained in surface runoff or irrigation return flows from farmed areas upstream of the park. Four of the seven stations were sampled under the auspices of the LTEM (Long Term Ecological Monitoring) macroinvertebrate monitoring program (Harris and others, 1990). Two of the seven stations were sampled only one time.

Groundwater quality data are sparser than surface water data. Water quality samples are periodically collected from the wells providing public water supplies to park staff and visitors. The only potential groundwater contamination sources are the septic leach fields operated by the park.

The Upper Niobrara White Natural Resources District is conducting a groundwater quality investigation in the Box Butte / Mirage Flats irrigation area to improve the efficiency of irrigated agriculture and to increase public awareness of nonpoint source pollution and ground water contamination. The study area is downstream of the park and will not assess groundwater quality at Agate Fossil Beds.

Dr. Nels Troelstrup of South Dakota State University (SDSU) is developing a monitoring plan for Aquatic Ecosystems in the Northern Great Plains Network (http://www1.nature.nps.gov/im/units/ngpn/Pages/monitoring.htm). Aquatic resources at Agate Fossil Beds will be included in this monitoring program.

Geology and Groundwater Resources

The geology and groundwater resources of Agate Fossil Beds and the surrounding area are described by Bradley (1956). Site-specific hydrogeologic conditions are provided in unpublished USGS reports prepared in conjunction

with construction of the park's original water supply well in 1967 (Emery, 1966). The Niobrara River valley is underlain by up to 50 feet of alluvium. The alluvium overlies sand and silt sediments belonging to the Arikaree Group.

The park's water supply wells and nearby irrigation wells are constructed into the Arikaree Group, generally to a depth of 100-200 feet. Yields of 100-1000 gpm are common for wells constructed in the Arikaree Group. The park's original well was drilled to 240 feet deep and tested at 160 gpm for 30 hours resulting in 97 feet of drawdown. The potable water supply well and fire well in the maintenance area were constructed in 1992. Both wells are 180 feet deep. The potable supply well is 6-inch diameter and the fire well is 10-inch diameter. Both wells are screened starting at 90 feet below ground surface. The potable supply well will produce about 140 gpm at a pumping level of 90 feet below ground surface (the top of the well screen). The 10-inch fire well will produce 400 gpm with a pumping level of 76 feet below ground surface.

In general, groundwater in the alluvium along the river is closely interconnected with surface water flow in the river. Water table elevations in the alluvium probably closely mimic stream elevations, with a slight gradient toward the river. Flooding creates opportunities for recharge by infiltration of surface water over large flooded areas, followed by subsequent drainage of the shallow alluvial groundwater to the river. Rainfall and snowmelt provide another source of recharge to the shallow alluvial aquifer. There is a small component of groundwater flow toward the river. Discharge of groundwater to the river maintains baseflow in the stream and generally causes streamflow to increase in the downstream direction. Much of the groundwater in the alluvium probably remains in the alluvium, flowing downstream as a slow-moving underground river. The alluvium acts as a buffer to streamflow, accepting large quantities of recharge during wet periods and slowly releasing the water to the stream during dry periods.

Groundwater in the underlying sediments of the Arikaree Group is recharged by infiltration of rainfall on upland areas. Even though rainfall is low in the area, sandy soils allow rapid infiltration of water, resulting in significant recharge to underlying geologic formations.

In August 2002, a series of streamflow measurements were made through the park in an attempt to identify areas of significant groundwater inflow into the river. (These data are included in the appendices of this report.) The data were inconclusive in identifying the location of significant springs or seeps. The extreme drought conditions of the summer of 2002 may have contributed to the lack of significant groundwater flow to the stream. Alternatively, groundwater inflow to the river under baseflow conditions may be insignificant over the four miles encompassed by the park.

Issues

1. Streamflow gaging

The USGS operated a streamflow gaging station on the Niobrara River, at the Highway 29 bridge, from 1957-91 (Station Number 06454100). The site is near the upstream boundary of AGFO. From 1994-2004 the chart recorder at the gaging station was operated by park staff. However, data collection did not meet QA/QC standards for operating a streamflow gaging station. In FY-03, the USGS was contracted to conduct streamflow gaging at this site to evaluate the stage-discharge rating curve for the site. USGS also conducted repair and maintenance of the chart recorder and associated equipment to make certain that it was in good operating condition.

The charts from the recorder for the period from 1991-2004 were analyzed as part of the research for this report. However, the data have not been published anywhere in the public domain, and other parties will only discover the data by very persistent efforts or blind luck. These data have been published as an unofficial report and a limited number of copies have been provided to the park and Nebraska DNR and placed in WRD files. A copy of the data and hydrographs are included in Appendix 8 of this report.

In the fall of 2004, new equipment was installed to provide a continuous record of streamflow at the site. The gaging station will be operated and maintained by staff from Nebraska DNR. The data will be analyzed and published by DNR in their annual "Hydrographic Report." The digital recording equipment for the site was purchased by NPS.

2. Water table decline from groundwater pumping

Most of the irrigation wells along the Niobrara River are sufficiently distant from the park that they will not affect the water table elevation in the park. Two irrigation wells operated by the Skavdahl Brothers near the eastern park boundary may be an exception. Regular monthly monitoring of the water level in the domestic supply well for the park's eastern housing area and maintenance shop will provide an indication of whether (and how much) pumping groundwater for irrigation affects the water table in the park. Preliminary data (Figure 9) show an annual groundwater level decline and recovery of about 5 feet, but data are insufficient to determine whether this is a natural fluctuation or if it is caused by groundwater pumping from the irrigation wells. Park staff are continuing to make regular groundwater level measurements to allow analysis of this issue.

3. Groundwater/surface water interaction

There may be areas along the Niobrara River within the park where "springs" allow significant quantities of groundwater to flow into the river. If these springs occur in the stream channel, they would not be readily apparent by visual inspection. Spring discharge into the river could significantly change water quality for a short reach of the river, affecting stream biota. Precise measurement of streamflow at a series of locations along the river (a process usually referred to as a seepage run) could identify reaches of the river where significant streamflow changes indicate areas where groundwater is discharging to the river or water from the river is infiltrating into the groundwater system. An initial assessment did not reveal reaches of significant groundwater inflow into the river or seepage from the river into the groundwater system (Appendix 5).

References

AGFO, 2004, *Environmental Assessment to Rehabilitate the Park's Fire Protection, Potable Water Supply, and Water Treatment and Distribution System*, 36 pp.

Bradley, Edward, 1956, *Geology and Ground-Water Resources of the Upper Niobrara River Basin, Nebraska and Wyomin*g, U.S. Geological Survey Water-Supply Paper 1368, 67 pp.

Emery, Phillip A., 1966, *Reconnaissance Survey of the Geology and Ground-Water Resources of the Proposed Agate Fossil Beds National Monument, Sioux County, Nebraska*, U. S. Geological Survey unpublished report, 4 pp.

Harris, Mitchell A., Boris C. Kondratieff, and Terence P. Boyle, 1990, *Macroinvertebrate Assemblages and Water Quality in Six National Park Units in the Great Plains*, unpublished, 2 vols.

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NPS, 1998, *Baseline Water Quality Data Inventory and Analysis, Agate Fossil Beds National Monument*, National Park Service, Water Resources Division, Fort Collins, CO, Technical Report NPS/NRWRD/NRTR-98/151, 112 pp. plus appendices.

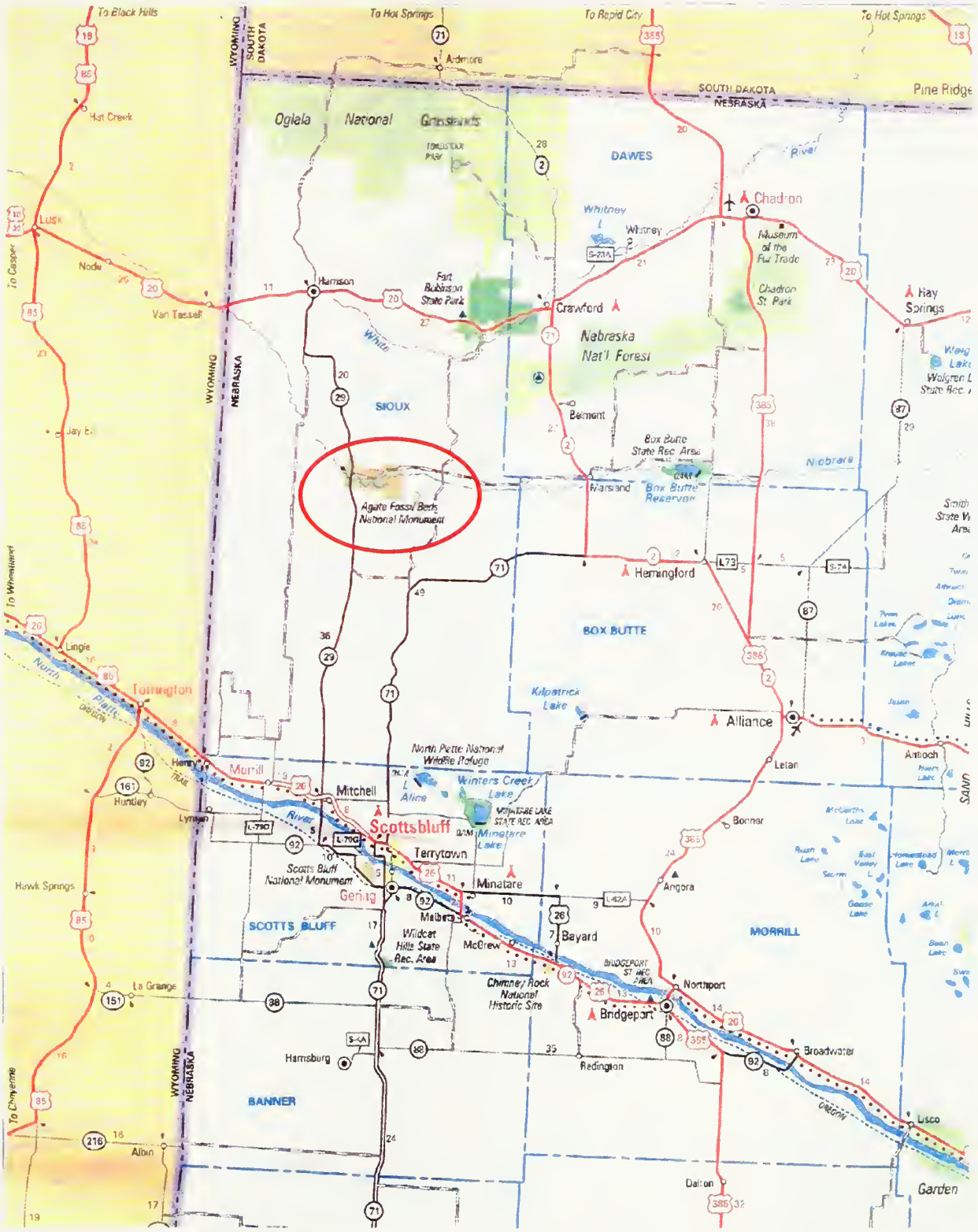


Figure 1. Location of Agate Fossil Beds National Monument in western Nebraska.

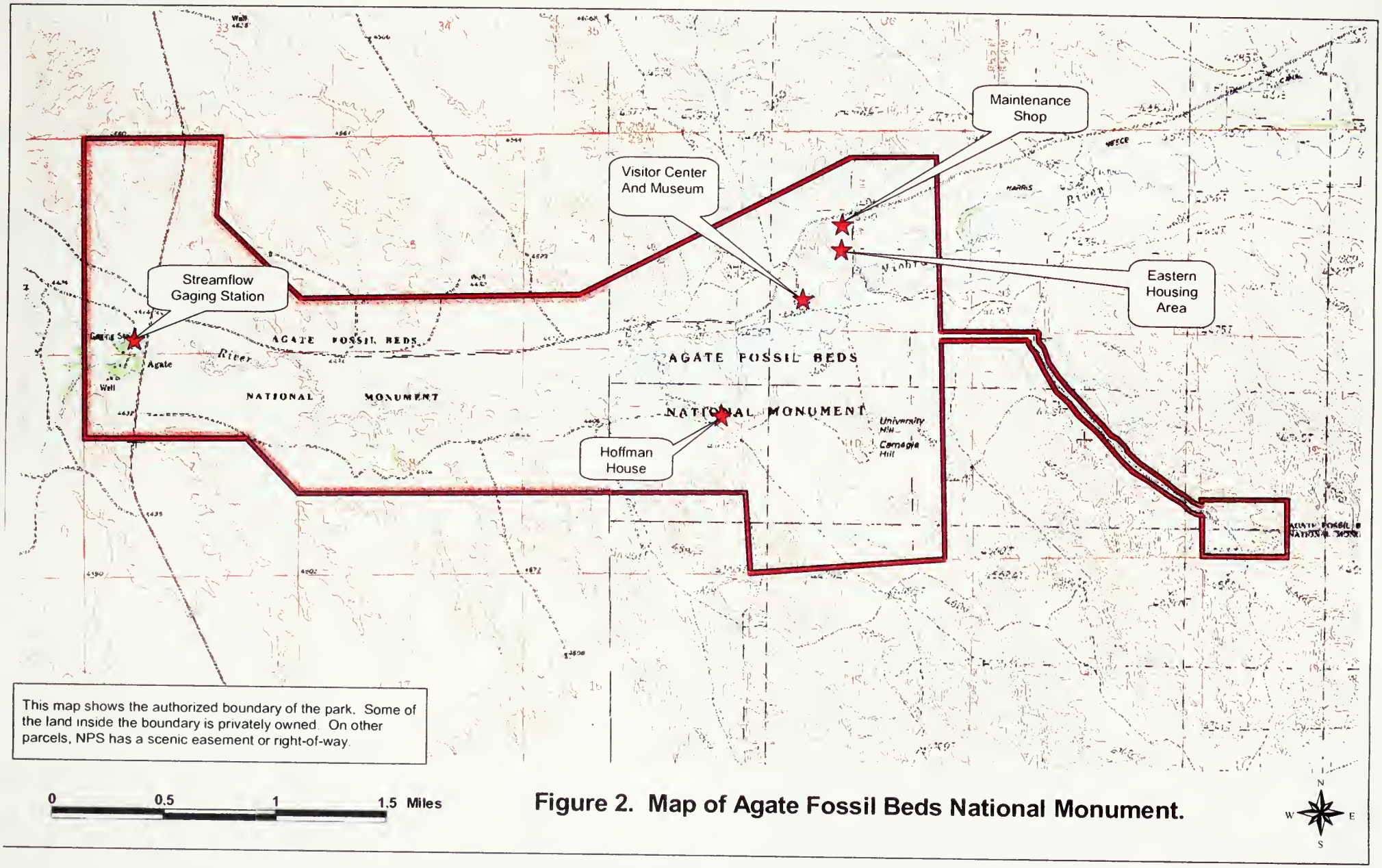
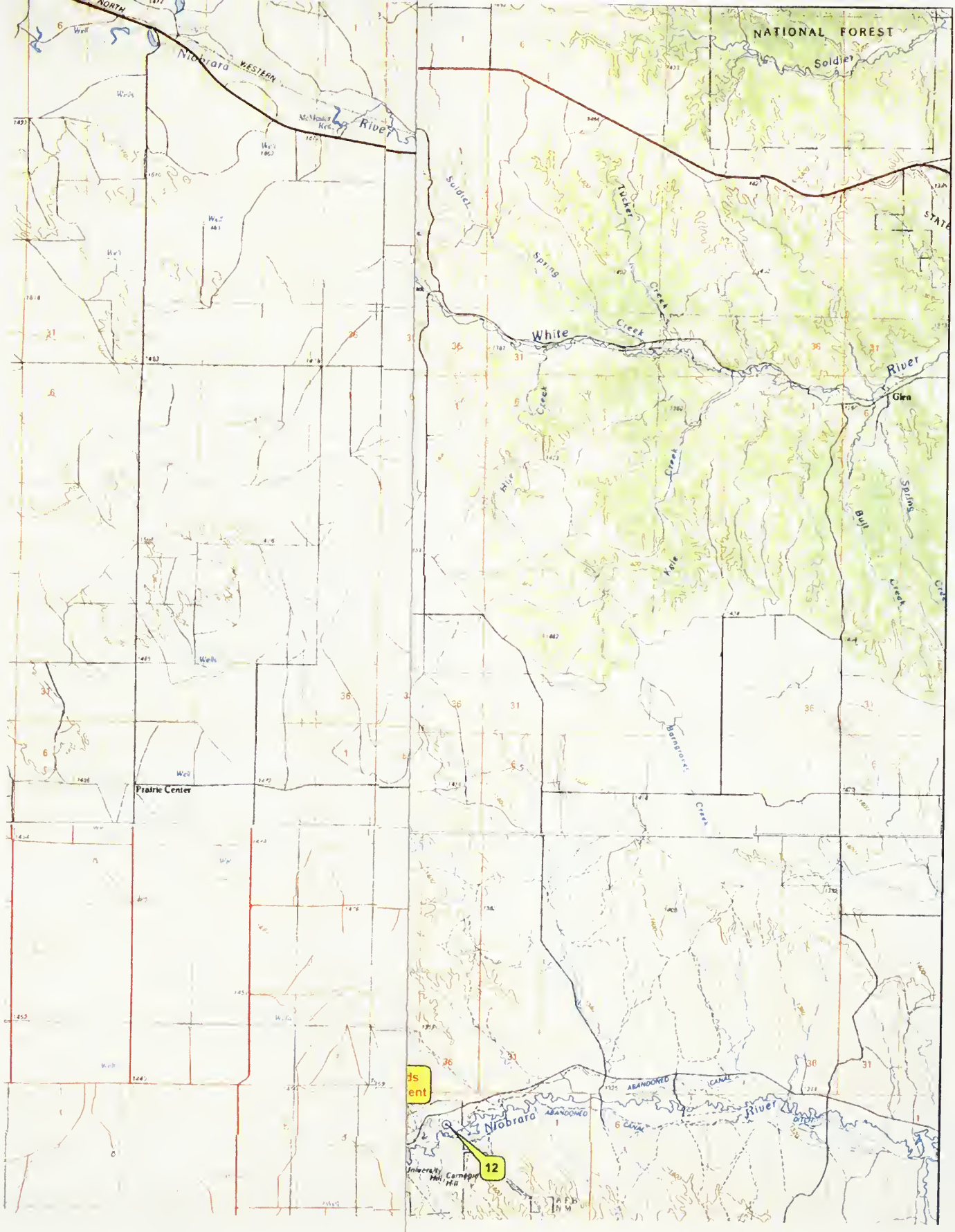


Figure 2. Map of Agate Fossil Beds National Monument.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Niobrara
River
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CANAL
12

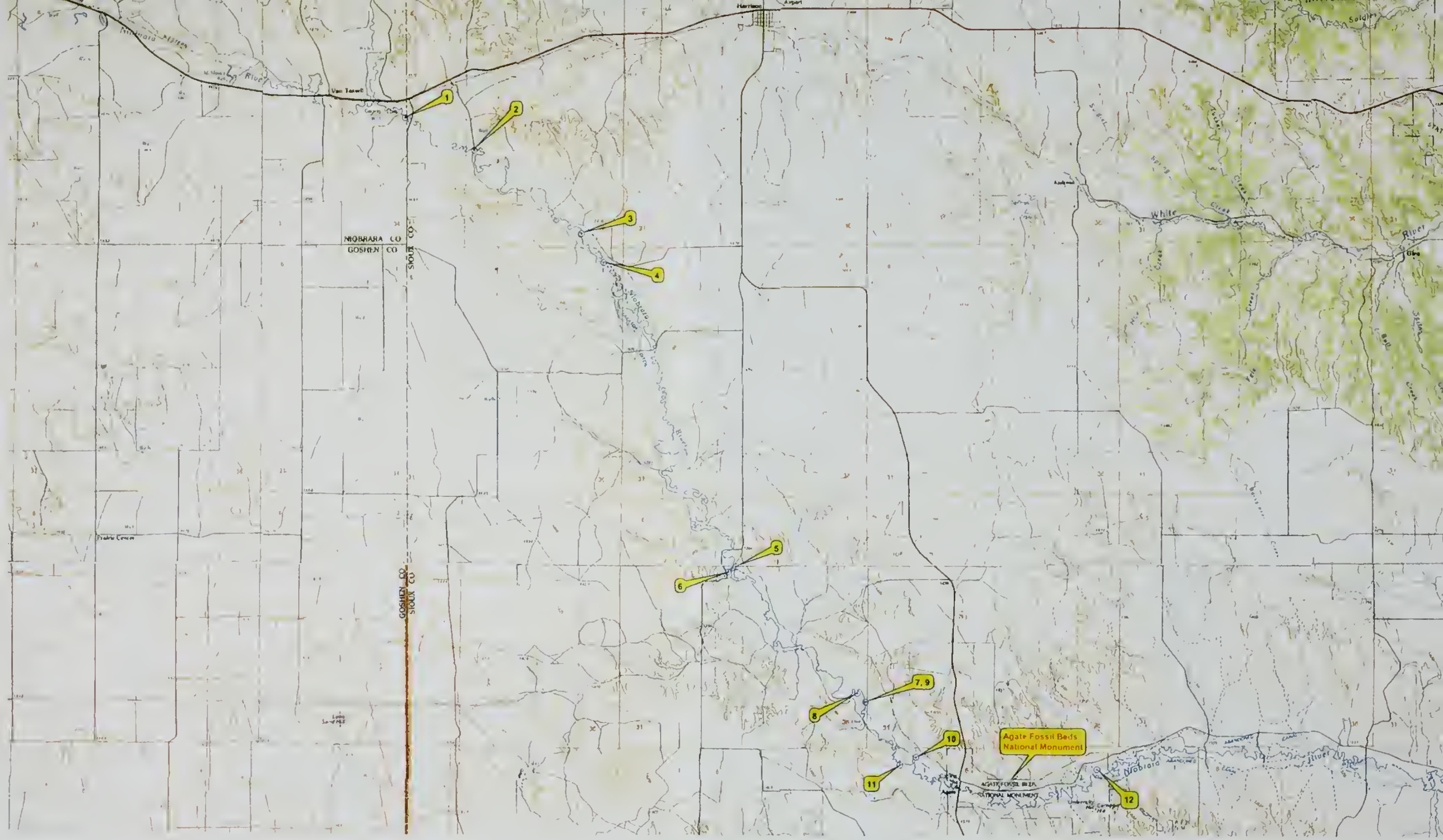
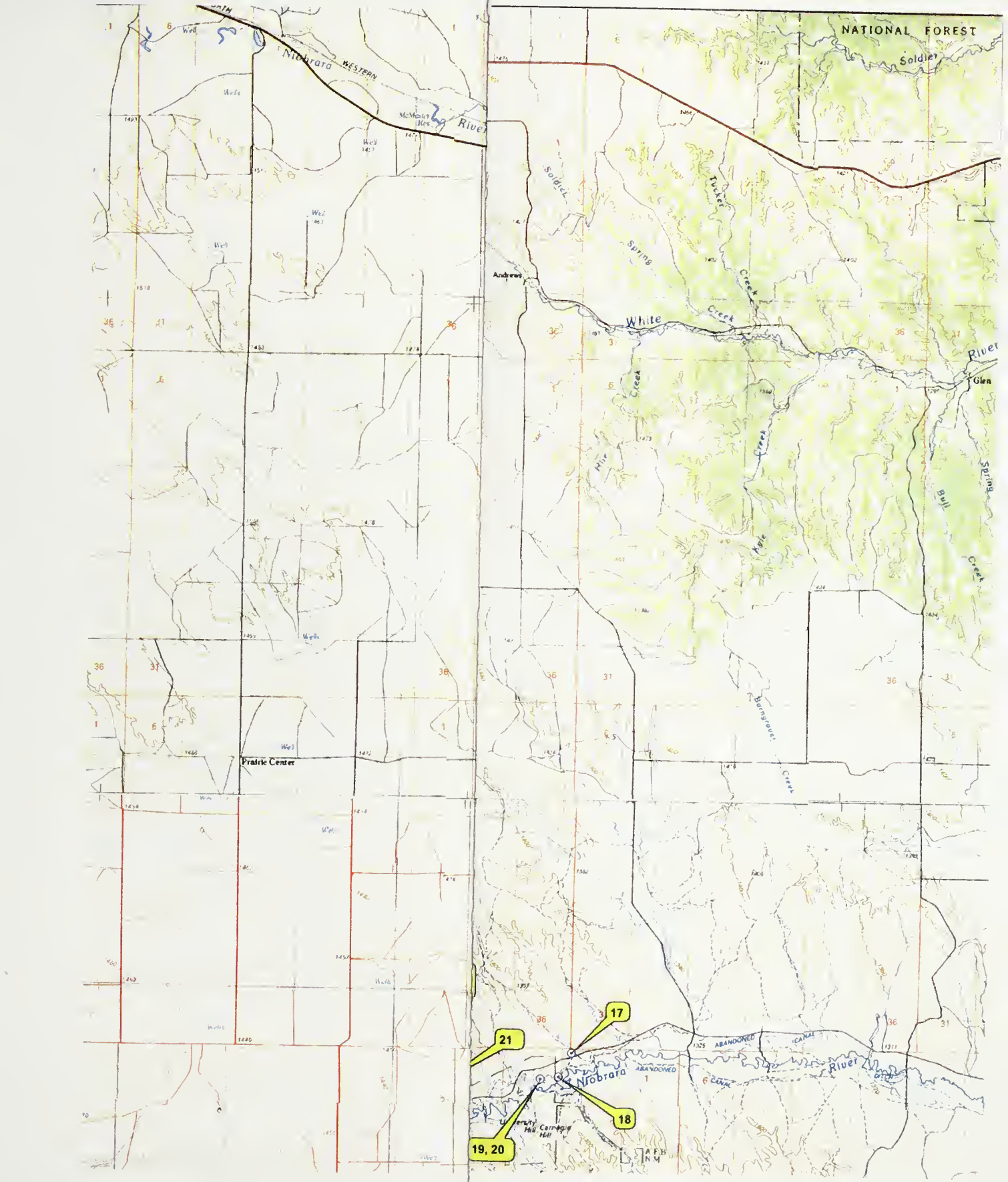


Figure 3. Location of surface water diversions from the Niobrara River.

Map ID numbers correspond to the ID numbers in Table 1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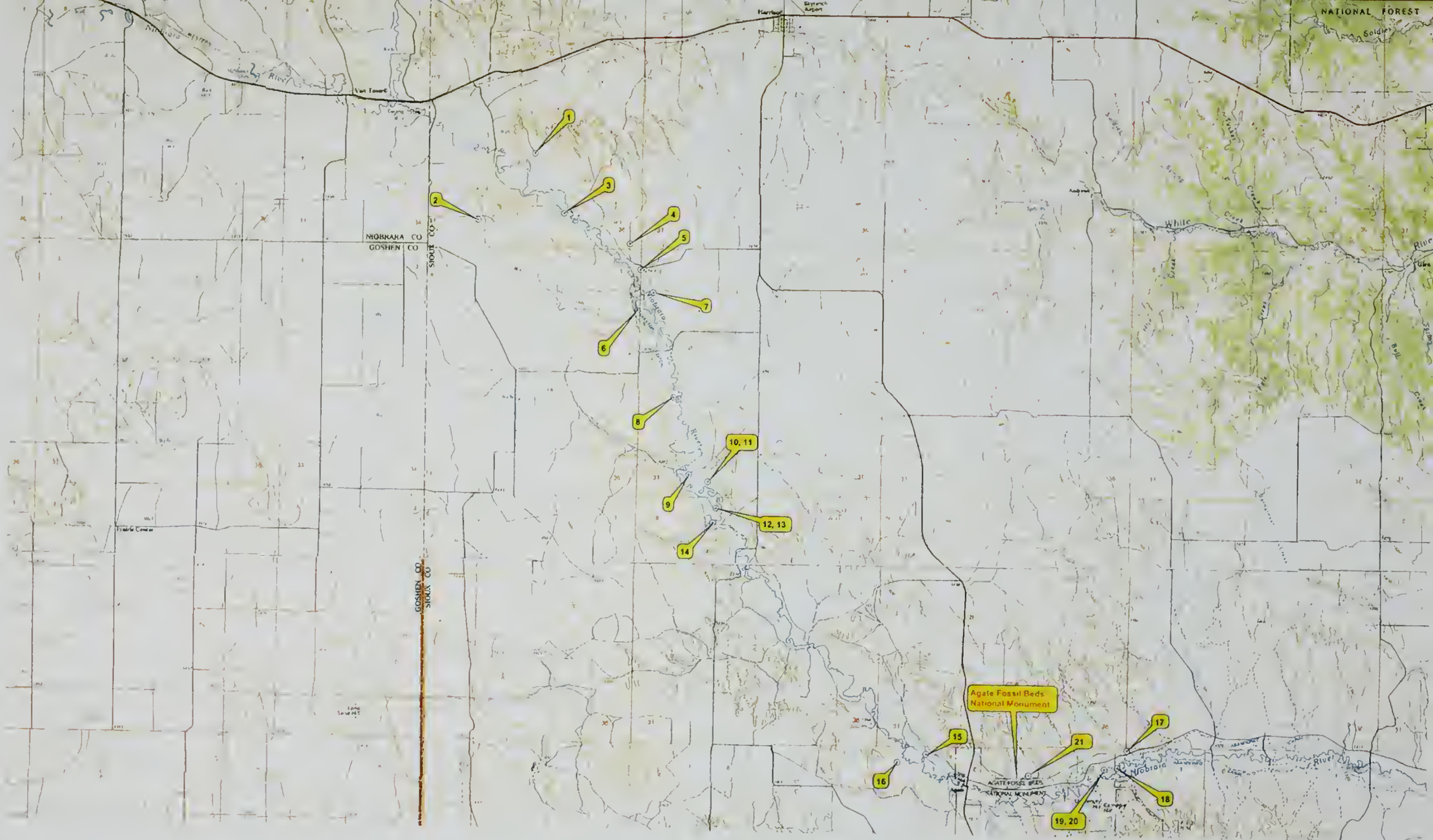


Figure 4. Location of registered water wells along the Niobrara River.

Map ID numbers correspond to the ID numbers in Table 1

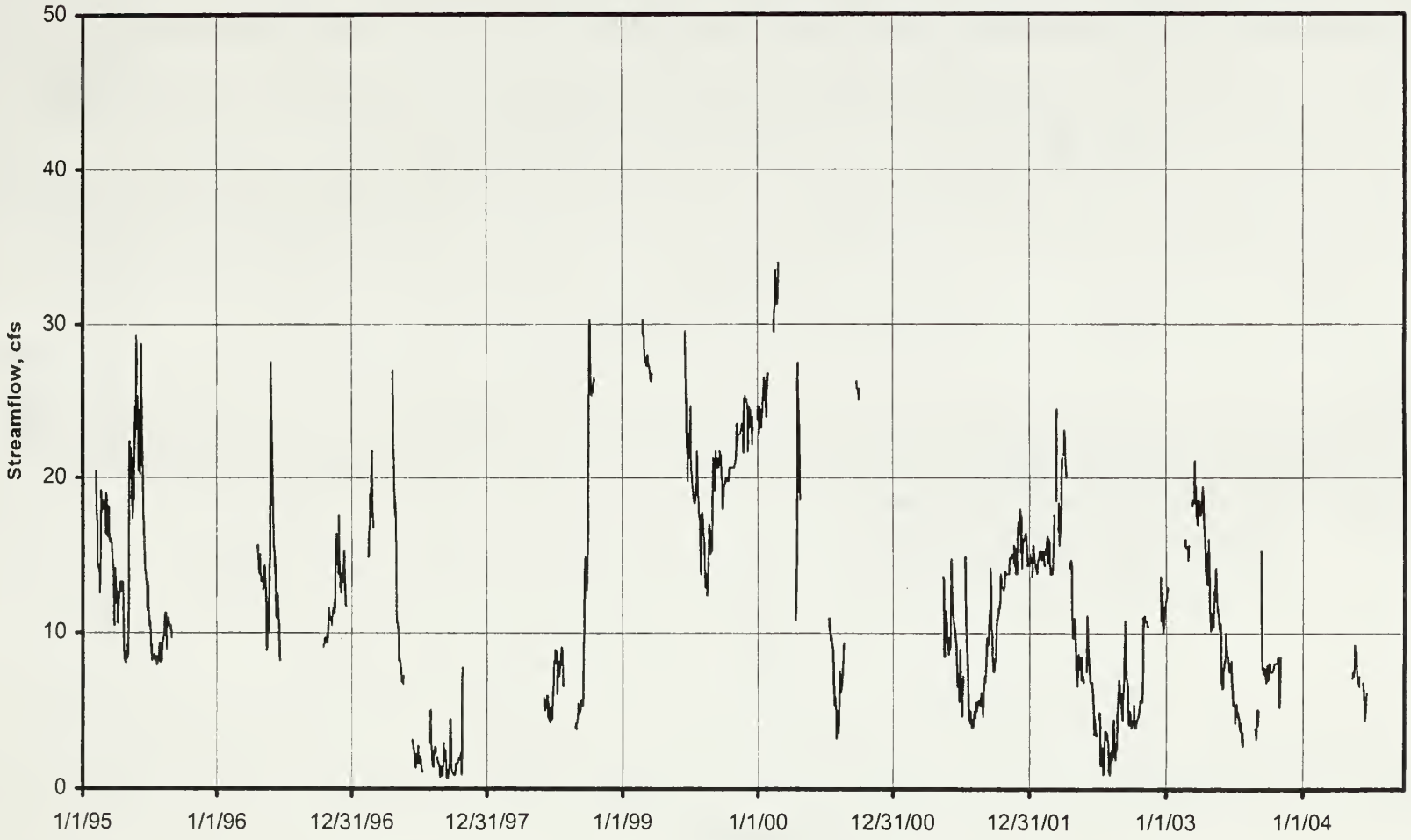


Figure 5. Streamflow in the Niobrara River during the period the gaging station was operated by NPS personnel

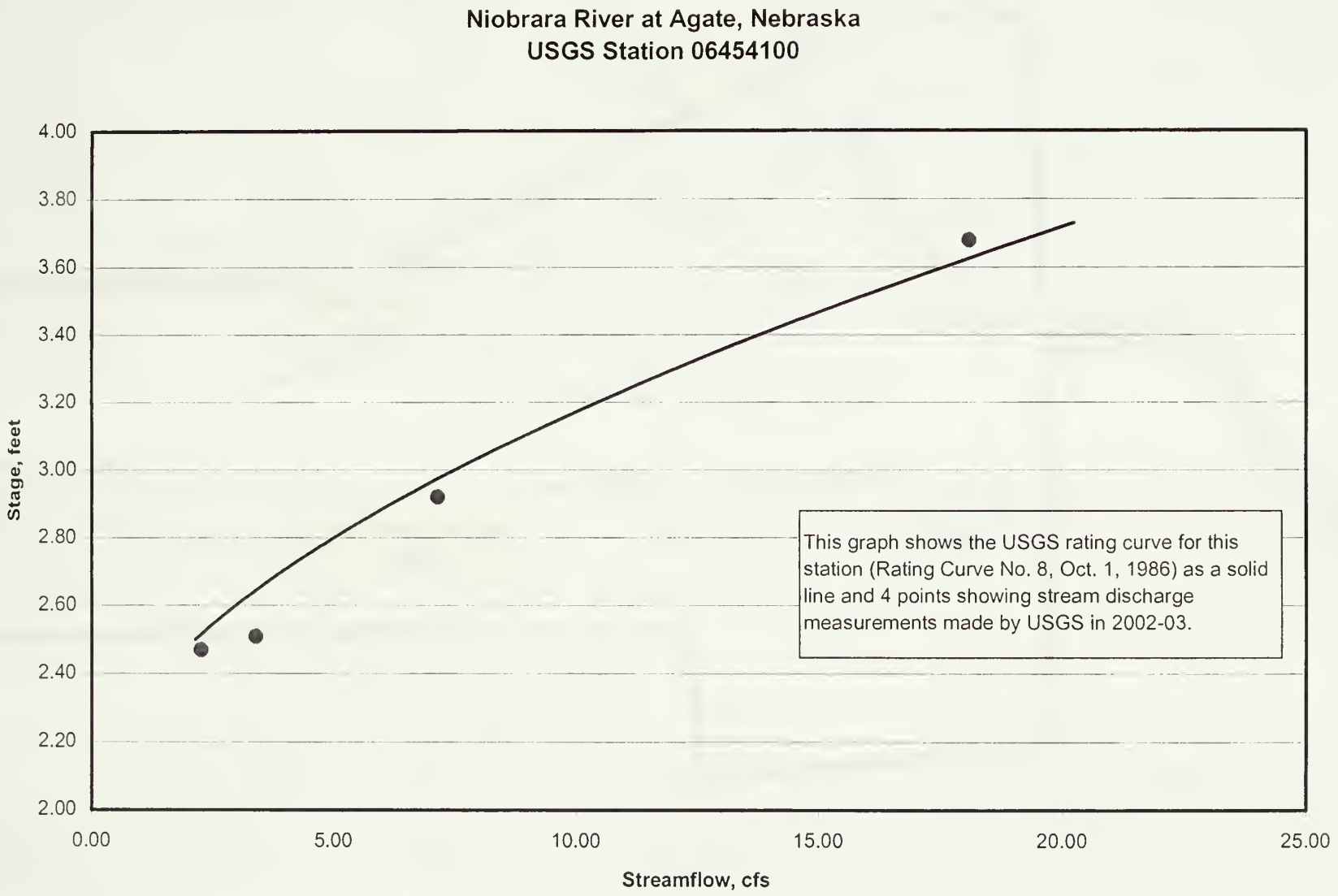


Figure 6. Rating curve for streamflow gaging station on the Niobrara River at Agate, Nebraska.

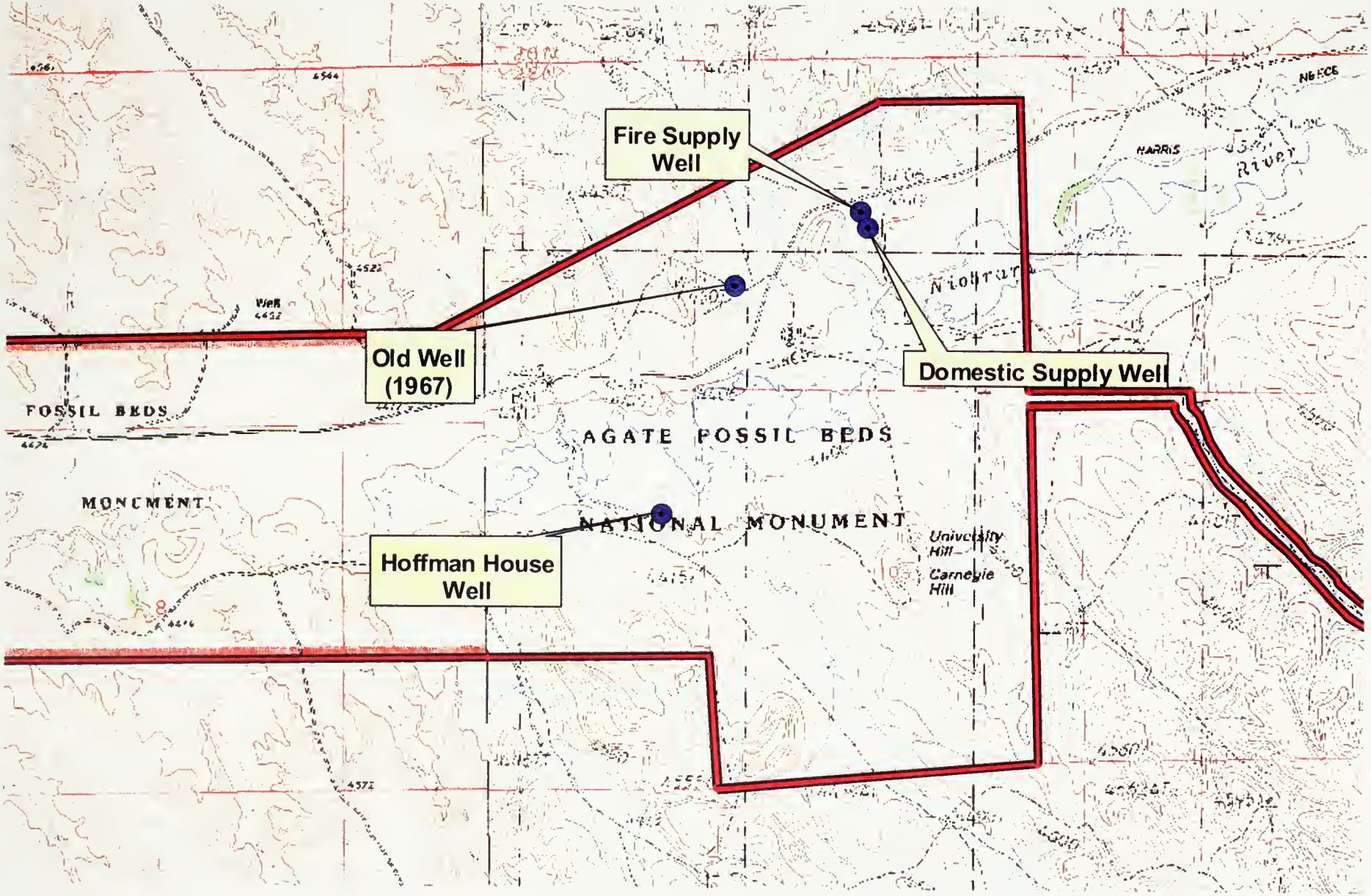


Figure 7. Well Locations at Agate Fossil Beds National Monument

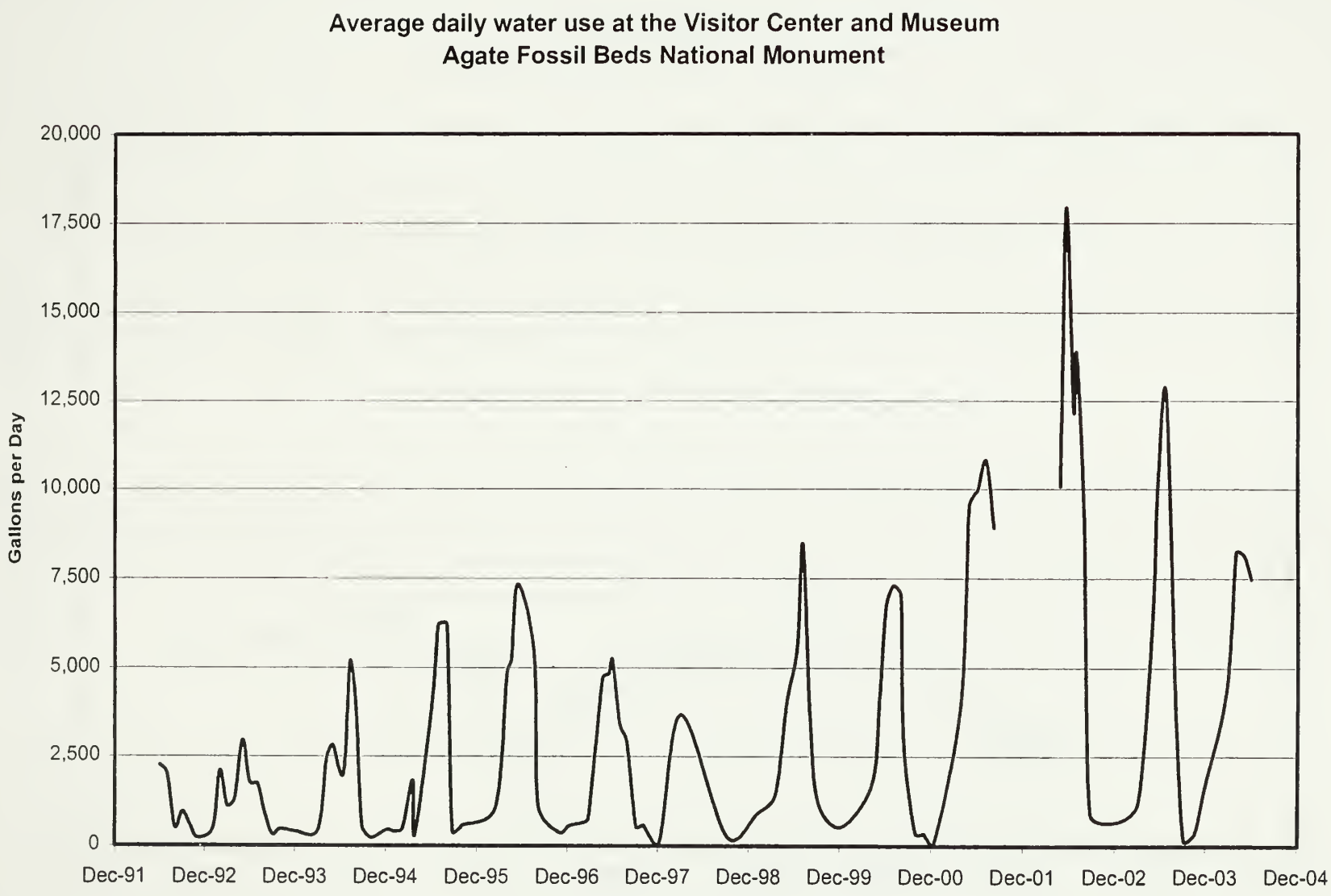


Figure 8. Average daily water use at the visitor center and museum.

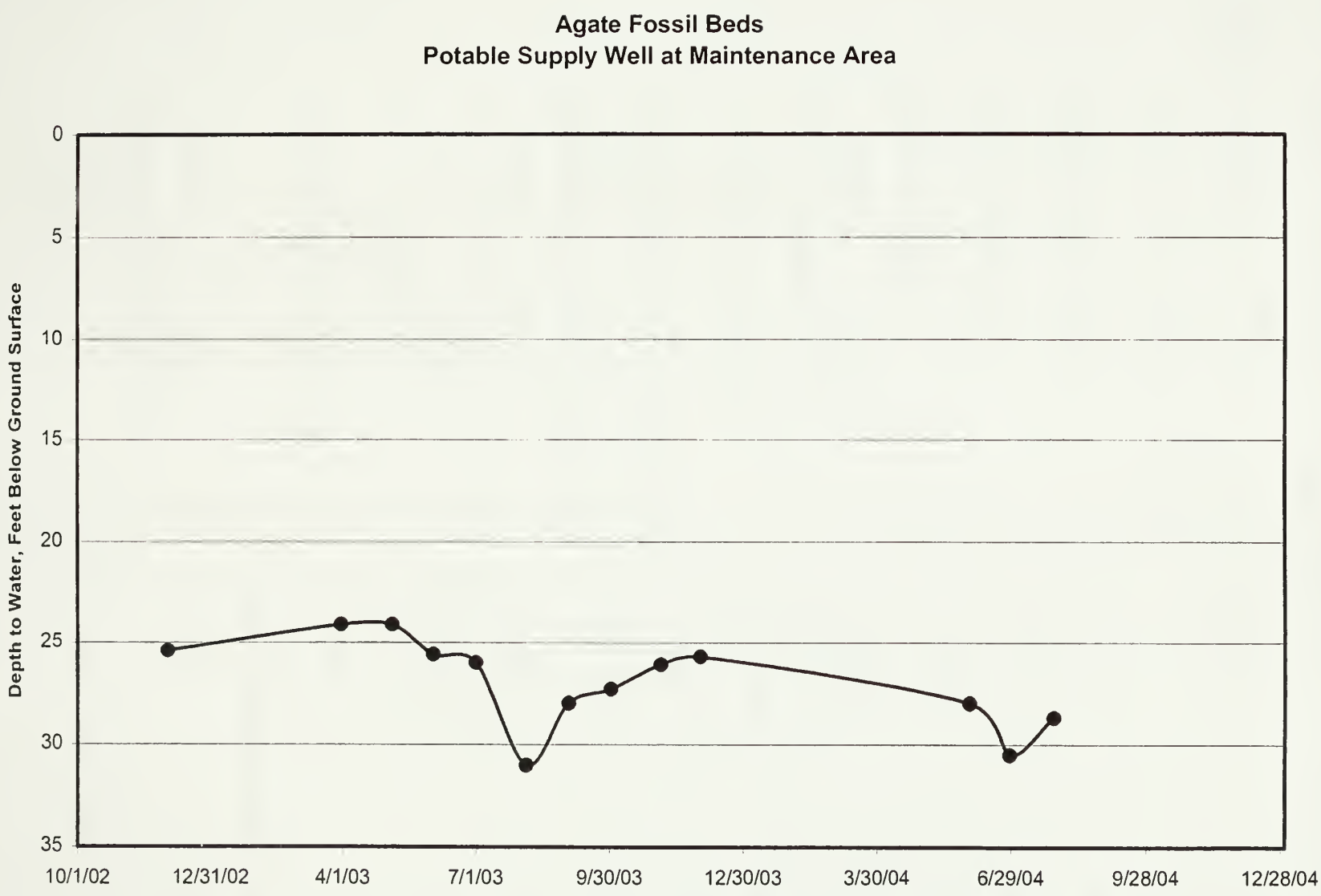


Figure 9. Depth to groundwater measured in the potable supply well in the maintenance area.

Table 1. Surface Water Rights on the Niobrara River from the Wyoming-Nebraska state line through Agate Fossil Beds National Monument

Map ID Number	Location Twn-Rge-Sec	Priority Date	Docket/ Appl'n Number	CFS	Irrigated Acres
1	31-57-19	6/8/1891	D-510	1.2	83.5
	Ellicott Hereford Ranch, Biglow-Seymour Canal				
2	31-57-21	6/8/1891	D-510 R	0.96	67.6
	Ray Dout Ranch & Cattle, Pumps				
3	31-57-35	5/1/1894	D-511 R, P-243	2.09	146
	Howard Juhl, Johnson Canal				
4	30-57-1	10/1/1883	D-554	5.76	404.5
	Melvin & Klara Grote, Lakotah Canal				
5	29-56-9	5/15/1891	D-514B	2.14	149.97
		3/24/2014	A1362 R, P-311	1.46	102.38
	Six Bar Ranch, Earnest Canal No. 2				
6	29-56-9	5/1/1885	D-514A, P-397	2.86	189.59
	Six Bar Ranch, Earnest Canal No. 1				
7	29-56-25	5/1/1887	D-513AR	5.06	354
	Agate Springs Ranch, McGinley-Stover N. Canal				
8	29-56-25	5/1/1890	D-513BR, T-754	1.34	94
	Agate Springs Ranch, McGinley-Stover S. Canal				
9	29-56-25	5/31/1891	D-980B	0.16	10.9
	Agate Springs Ranch, McGinley-Stover N. Canal and Cook Canal No. 2				
10	28-56-1	5/1/1887	D-513AR, P-430	1.48	103.4
		5/31/1891	D-980, P-428	0.52	36.1
	Agate Springs Ranch, Pump				
11	28-56-2	5/31/1891	D-980A	2.31	162.1
	Agate Springs Ranch, Cook Canal No. 1				
			Total Upstream of Park	**27.34**	**1904.04**
12	28-55-3	7/1/1892	D-517	7.13	499
		7/11/1932	A-2275	2.54	177
	William Skavdahl, Harris-Neece Canal				
			Total Downstream of Park	**9.67**	**676**

Table 2. Streamflow and Irrigation Diversions from the Niobrara River, acre-feet

WATER YEAR	FLOW AT WYOMING-NEBRASKA BORDER	DIVERSIONS BETWEEN BORDER AND AGATE	DIVERSIONS AT HARRIS-NEECE CANAL
2003	2220	1655	1350
2002	2200	1522	1610
2001	2430	1170	1780
2000	2750	2149	1620
1999	3010	2093	1500
1998	2670	1778	1450
1997	2710	1982	2040
1996	2340	2751	1540
1995	2670	2830	1540

Data were obtained from the annual Hydrographers Report published by the Nebraska Department of Natural Resources. Streamflow is measured at a gaging station at the Wyoming-Nebraska border, about 25 miles upstream from Agate Fossil Beds. Diversions between the state border and the monument are listed in Table 1. The Harris-Neece Canal diversion point is at the downstream boundary of the park fee lands.

Table 3. Registered Groundwater Wells within about 1 mile of the Niobrara River from the Wyoming-Nebraska state line to downstream of Agate Fossil Beds National Monument.

Map ID Number	Owner	Location Twn-Rge-Sec	Completion Date	Registration Number	Pumping Rate, gpm	Irrigated Acres
1	Derrick Keim	31-57-22-SW Center	4/1/1995	G-103502	3	0
2	Mike Wickersham	31-57-32-SENE	6/10/1997	G-094534	70	---
3	Boggs and Hanson	31-57-35-SWNW	6/15/1955	A-007766	---	120
4	Derrick Keim	31/57/36-SWSE	8/5/2003	G-123492	1500	65
5	Blanche Parsons	30-57-01-NESE	3/18/1955	A-007352	2000	200
6	Melvin Grote	30-57-12-SENE	8/1/1976	G-051391	882	200
7	Blanche Parsons	30-56-07-NENW	6/1/1952	A-006658	2000	240
8	Melvin Grote	30-56-19-NWSE	8/1/1976	G-051392	800	200
9	Nature Conservancy	30-56-32-NESW	2/19/1998	G-096226	300	56
10	Nature Conservancy	30-56-32-NWSE	4/2/1998	G-096227	500	92
11	Nature Conservancy	30-56-32-NWSE	2/24/1998	G-096228	200	37
12	Nature Conservancy	29-56-05-SENE	10/8/1975	G-050129	300	70
13	Nature Conservancy	29-56-05-SENE	7/23/2001	G-050129	650	77
14	John Bourret	29-56-05-NESE	7/1/1955	A-008099	---	140
15	James Skavdahl	28-56-01-NENW	11/13/2003	G-125399	---	100
16	James Skavdahl	28-56-02-SENW	5/15/1995	G-086641	2	---
17	Skavdahl Bros.	28-55-03-NENE	11/3/1978	G-096055	950	80
18	Skavdahl Bros.	28-55-03-SWNE	10/10/1978	G-096056	600	180
19	National Park Service	28-55-03-SENW	10/8/1992	G-079952	300	---
20	National Park Service	28-55-03-SENW	10/1/1992	G-079953	80	---
21	Buckley Bros.	28-55-05-NWSE	3/15/1955	A-007276	---	150

Appendix 1

Reconnaissance survey of the geology and ground-water resources of the proposed Agate Fossil Beds National Monument, Sioux County, Nebraska, May 31, 1966

Includes a reconnaissance report by the USGS and correspondence between USGS and NPS personnel regarding the proposed location and construction of a water supply well.

May 31, 1966

RECONNAISSANCE SURVEY OF THE GEOLOGY AND GROUND-WATER RESOURCES OF THE PROPOSED AGATE FOSSIL BEDS NATIONAL MONUMENT, SIOUX COUNTY, NEBRASKA

by

Philip A. Emery
Geologist
U.S. Geological Survey

Geology and General Availability of Ground Water

Rocks ranging in age from Miocene to Quaternary are exposed within the proposed park boundary. The best and most readily available aquifer is the Recent alluvium and adjacent parts of the terrace and colluvial (slope-wash) deposits. (See fig. 1.) This aquifer is capable of yielding small to moderate amounts of water. The lower part of the Arikaree Group (see table 1) would most likely yield the greatest amount of ground water, perhaps as much as 500 gallons per minute. The irrigation well shown on figure 1, in section 5, probably obtains its water from Arikaree rocks. The bottom of the Arikaree Group, or Miocene, within the park boundary, is estimated to be at an altitude of approximately 4,250 feet. Below this contact the possibility of obtaining adequate supplies of good-quality water decreases and is nearly nonexistent below the top of the Pierre Shale of Cretaceous age.

Following is a log of an oil company test hole drilled approximately three-fourths of a mile south of the southeast corner of the proposed park boundary. It is included in this report because the subsurface geology of the park area may be expected to be similar to that at the test-hole site. However, since the park area is at a lower altitude, the stratigraphic contacts designated would be nearer the land surface.

Generalized log of test hole, Union Oil Co. of California, Agate test No. 15-1, drilled August 1938 in NW¼SE¼SE¼ sec. 15, T. 28 N., R. 55 W. Altitude of land surface, approx. 4,695 feet, total depth, 6,846 feet.

	Depth below land surface (in feet)	
	From	To
Tertiary System		
Miocene Series		
Arikaree Group	0	410
Oligocene Series		
White River Group	410	960
Cretaceous System		
Upper Cretaceous Series	960	4,625
Lower Cretaceous Series	4,625	4,965
Jurassic System		
Upper Jurassic Series	4,965	5,409
Triassic System	5,409	5,785
Permian System	5,785	6,846

Chemical Quality of Ground and Surface Water

Analyses of samples of ground and surface water taken in and near the park area indicate that both are of good quality for domestic and irrigation uses. (See table 2.) The water is hard, but should present no problems for the intended uses.

Ground-Water Supply for the Proposed Park Headquarters Area SW¼ sec. 3, T. 28 N., R. 55 W.

A proposed well site, which was already selected before my arrival at the park area and referred to as Site No. 1, is located on an alluvial-colluvial terrace approximately 250 feet north of the south edge of the terrace which stands 15-18 feet above the present river flood plain. The surface of the terrace is slightly hummocky and has a general slope upward away from the stream 1-2° NNW. The depth to water at this site probably is between 15-20 feet, and the thickness of the alluvial-colluvial fill probably is between 30-50 feet. If an adequate supply of water cannot be obtained from this material, it is possible to drill deeper and obtain the required amount from the underlying bedrock.

The exact site of the proposed septic tank and disposal field was not designated. The location of the tank and disposal field was discussed with Mr. R. C. Wyrick of the National Park Service; and a likely site, based on the general location given on the general-development-plan map and our examination of the topography of the area, was postulated. The direction of ground-water movement in the area of Well Site No. 1 and the disposal field is to the southeast and south toward the Niobrara River. To eliminate any possible chance of contamination to the water supply the disposal field should be located east of a line running N. 15-20° E. of the well site. If possible, either Well Site No. 1 should be moved westward or the disposal site moved eastward to avoid potential contamination.

Ground-Water Supply for Picnic Area near Agate Springs Ranch

Little difficulty should be experienced in obtaining an adequate amount of ground water in the picnic area. The depth to water is only about 5-10 feet and the saturated sediments should be sufficiently permeable to yield small supplies of water. However, inasmuch as a cattle feed lot and recently installed privies apparently are upgradient from the picnic area, strong possibilities exist for contamination of the ground-water supply. To avoid these possibilities of contamination, the well should be installed at a higher elevation to the southwest, perhaps near the proposed storage-tank site. A well installed in this locality would, of course, derive water from the bedrock formations, and depth to water probably would be between 80 and 100 feet.

If it is necessary to install the well within the picnic grounds it should be located as far as possible from the toilets and feed lot, and the water should be periodically sampled and analyzed for contamination.

Table 1.--Generalized section of the Quaternary and Tertiary rocks within the proposed Agate Fossil Beds National Monument.

System	Series	Stratigraphic unit or subdivision		Approximate thickness (feet)	Character, distribution, and water supply
Quaternary	Recent and Pleistocene	Alluvium and colluvium, undifferentiated		0-50	Flood-plain deposits of clay, silt, sand, and grave' slope-wash and talus deposits consisting of poorl· sorted, locally derived bedrock fragments. (In n t areas this material should yield water readily to wells; this is especially true near the river and the adjacent parts of flanking terraces.)
Tertiary	Miocene	Arikaree Group	Harrison Formation	100-400	Gray, poorly cemented, fine-grained sand and silt; some "pipy" concretions in lower part; fossil quarries in lower part; "Devil's Corkscrews" in the upper part.
			Monroe Creek Formation		Reddish-brown to buff sandy silt and clay with layers of thick-bedded gray sand and many "pipy" concretion zones. (Where saturated should yield water readily to wells.)
			Gering Formation		Gray, fine- to medium-grained sand, often crossbedded; may or may not be present in Park area. (If presen should yield abundant water to wells.)
	Oligocene	White River Group	Brule Formation	550-600	Pink, massive, silty clay, with thin layers of volcanic ash and fine sand. (Yields water only if fractured.)
			Chadron Formation		Green to buff clay and silt; channel sandstone locally found at base. (Yields very little, if any, water to wells.)
Cretaceous	Upper Cretaceous	Pierre Shale Formation		2,500±	Black and gray clay shale with a few thin sandstone beds in upper part. (Nearly impossible to obtain water from this unit; any obtained would be of poor quality.)

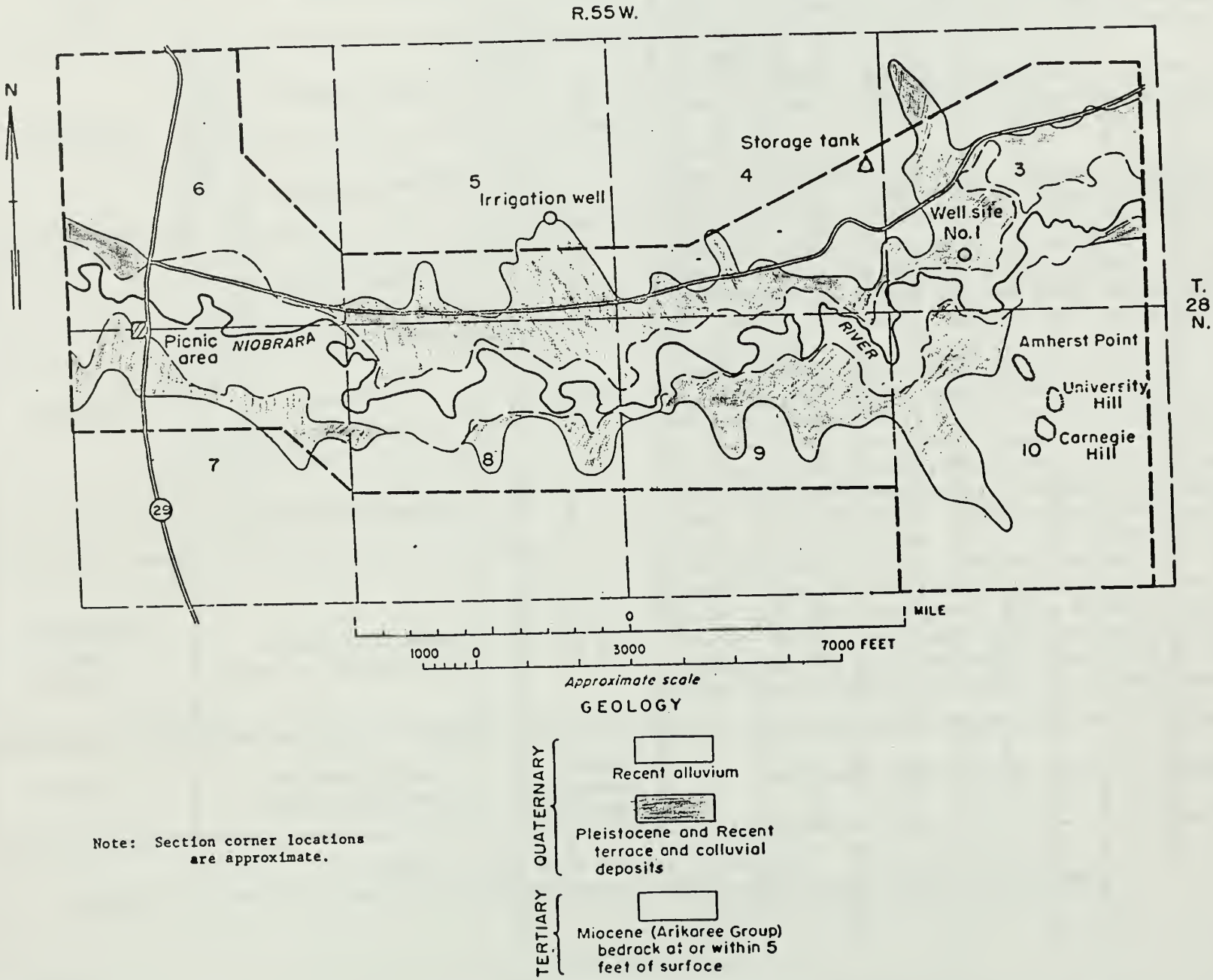


Figure 1.--Reconnaissance geologic map of proposed Agate Fossil Beds National Monument, June 1966.

Table 2.--Chemical analyses of ground and surface water in the vicinity of the proposed Agate Fossil Beds National Monument.
[Analytical results in parts per million except as indicated]

Location	Source	Depth of well (feet)	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$		Percent sodium	Specific conductance (micromhos at 25°C)	pH
																	Calcium magnesium	Noncarbonate			
NW¼SW¼ sec. 6, T. 28 N., R. 55 W. (Agate, Nebr.)	Quaternary alluvium	13	11-22-36	..	....	47	11	21	...	196	22	5.0	0.6	20	....	223	163	..	..	...	...
SW¼NW¼ sec. 6, T. 28 N., R. 54 W. (2 miles E of park)	.....do...	45	10-8-52	50	0.37	45	7.4	20	6.8	192	19	5.5	.7	18	0.04	268	143	0	22	352	8.0
NE¼NW¼ sec. 19, T. 29 N., R. 53 W. (8 miles NE of park)	Arikaree Group	207	10-8-52	55	.17	39	7.2	7.8	4.4	161	5.0	5.5	.3	3.6	.02	216	127	0	11	273	8.1
SW¼SE¼ sec. 29, T. 27 N., R. 54 W. (10 miles SE of park)	.....do...	165	10-7-52	46	....	46	7.8	7.2	3.5	165	4.0	6.5	1.3	12	.03	238	147	12	9	311	7.9
Niobrara River at Agate, Nebr.1/	River	...	10-8-52	53	....	..	....	19	8.1	...	....	...	...	....	....	306	188	0	17	419	8.5

1/Estimated flow at time of collection, 10 cfs.

cc:
Superintendent, Scotts Bluff
Regional Director, MW Region w/c of report
Chief, Branch of Water Resources, WASO w/c of report
Chief, D&C, SSC w/c of report

Manual Morris

SAN FRANCISCO PLANNING AND SERVICE CENTER
Office of Land and Water Rights
450 Golden Gate Avenue, Box 36063
San Francisco, California 94102
June 6, 1966

L54 LWSSC
Agate Fossil Beds

Morris

Memorandum

To: Mr. Kenneth A. Mac Kichan, District Chief, USGS
Nebraska Hall, 901 N. 17th St., Lincoln, Nebraska 68505

From: Supervisory Hydraulic Engineer, SSC

Subject: Water resources investigations - Agate Fossil Beds

I wish to express our appreciation to you, Mr. Philip A. Emery and Mr. H. M. DeCrew for the cooperation in furnishing this report on the limited advance notice we were able to give you.

We plan to drill a test well, based on Mr. Emery's report, at the proposed Park headquarters as soon as specifications can be issued. The sequence of related activities will probably require the bid opening date be set for early July, 1966.

There was a misunderstanding as to pre-selection of the well site for the proposed Park Headquarters Area. This may have affected the choice Mr. Emery might otherwise have made. In general, the Survey is free to make its own recommendations, selecting sites--based on their professional judgment--that are capable of yielding the end result described by us. We may, in some cases, ask you to consider a preferred location along with your own recommendation. The pre-selected site, Well No. 1, was just such a case. In view of the reservations Mr. Emery makes in the final two sentences on Page 3, would he prefer another location?

Your assistance will soon be requested for supervision of the drilling and testing. Thanks again.

(Sgd) MANUEL MORRIS

Manual Morris

cc:
Superintendent, Scotts Bluff w/c of report
Regional Director, MW Region w/c of report
Chief, Branch of Water Resources, WASO w/c of report
Chief, D&C, SSC w/c of report

MMorris:pm

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
WASHINGTON, D.C. 20240

IN REPLY REFER TO:
L54-SLW

June 17, 1966

Memorandum

To: Supervisory Hydraulic Engineer, SSC

From: Chief, Branch of Water Resources

Subject: Water Resources Investigations, Agate Fossil Beds

Please refer to your memorandum of June 6 to Mr. Mac Kichan, U. S. Geological Survey and the report by Mr. Emery on the ground water resources of Agate Fossil Beds National Monument.

Although the author describes the Recent alluvial and associated deposits as the "best" aquifer, the data in the report suggests that the Arikaree is the best. The Recent alluvial deposits are "capable of yielding small to moderate amounts of water" whereas the Arikaree "would most likely yield the greatest amount of ground water." The analyses in table 2 show very little difference in quality of water from the two aquifers with perhaps the water from the Arikaree being slightly less mineralized.

The only advantages in tapping the Recent alluvium rather than the Arikaree is the lesser depth of the well and possibly a lesser lift to the surface. If the water needs of the monument are not great these may outweigh the greater yield of the Arikaree. However, the author raises the possibility of pollution from the septic tank. A well into the Arikaree, properly cased and cemented through the Recent deposits, would be safe from such pollution.

Your memorandum indicates that a test well will be drilled in early July. You should consider testing both the Recent deposits and the Arikaree before a production well is decided upon.

Thank you for sending us a copy of the report. We shall be interested in the proposed test well and, also, in view of your memorandum, in learning whether Mr. Emery changes his recommendations.

E. W. Reed

cc:
Regional Director, Midwest
Superintendent, Scotts Bluff

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY
Water Resources Division
Room 127 Nebraska Hall
901 North 17th Street
Lincoln, Nebraska 68508
June 20, 1966

AIRMAIL

Memorandum

To: Manuel Morris, Supervisory Hydraulic Engineer, SSC
Office of Land and Water Rights, NPS, San Francisco, Calif.

From: District Chief, WRD, Lincoln, Nebr.

Subject: Water resources investigations - Agate Fossil Beds

In reference to your letter of June 6, it is my opinion that maximum protection from contamination would be achieved if well site #1 were moved at least 1,000 feet due west of the preselected site.

FOR THE DISTRICT CHIEF:

Philip A. Emery

Philip A. Emery

cc: Richard Holder, Superintendent
National Monument
Scotts Bluff, Nebr.

SAN FRANCISCO PLANNING AND SERVICE CENTER
Office of Land and Water Rights
450 Golden Gate Avenue, Box 36063
San Francisco, California 91402
June 23, 1966

LS4-LWSSC
(General-AGFO)
Memorandum

Morris

To: Assistant Director, Specialized Services
Attention: Chief, Branch of Water Resources

From: Supervisory Hydraulic Engineer, L&W, SSC

Subject: Water Resources Investigations, Agate Fossil Beds

Further to our recent exchange on well sites at the subject area, USGS Geologist Philip A. Emery advises, ". . . it is my opinion that maximum protection from contamination would be achieved if well site #1 were moved at least 1,000 feet due west of the pre-selected site."

Your memorandum of June 17, raises the question of choice of aquifers. The requirement is for 20 to 50 gpm and, if test drilling the recent alluvials fails to yield these quantities, drilling would be expected to continue, at the same site perhaps, into the Arikaree. The specifications and bid schedule will be designed to accommodate this contingency.

By copy of this memorandum, the Chief, D&C, SSC is being advised that the test well site will be relocated in accordance with Mr. Emery's recommendation, unless we receive contrary advice.

(Sgd) MANUEL MORRIS

Manuel Morris

cc: Regional Director-MWR
Superintendent, Scotts Bluff

MMorris:ll

Appendix 2

Memo describing construction of Well #1, July 19, 1968

Memo report describing construction and testing of a water supply well at the park. includes a detailed geologic log

IN REPLY REFER TO:

L54 GN SSC
AGFU
USGS

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
Rm. 127, Nebraska Hall
901 North 17th Street
Lincoln, Nebraska 68508
July 19, 1968

Memorandum

To: Mr. J. W. Roberts
National Park Service
San Francisco, Calif. 94102

From: District Chief, WRD
Lincoln, Nebr.

Subject: Agate Fossil Beds, Nebraska

In accordance with your request that this office supervise the drilling and test of Well #1 at the Agate Fossil Beds site the following is submitted. Information thus contained is for administrative use. No formal report is contemplated.

The test was conducted at the location of NW¼NW¼SW¼ sec. 3, T. 28 N., R. 55 W. in Sioux County. The well was drilled in July 1967 and tested for performance August 7-9, 1967. Samples of the rock materials drilled were obtained. The upper 89.5 feet was sampled by H. M. DeGraw, geologist. The driller, George Snyder, caught samples from 89.5 feet to the 193-foot depth. Difficulties with mud circulation attributed to fracture zones occurred during the drilling. Circulation was lost a number of times, particularly at a depth of 41 feet, 66 feet, and 193 feet. At the 66-foot depth it was necessary to fill the 4-inch test hole with concrete and redrill with an 8-inch bit with which the hole was finally completed to the 240-foot depth.

A description of the drill samples is attached. Microscopic examination in the laboratory was made by H. M. DeGraw who has been making an intensive study of the Tertiary rocks of northwest Nebraska.

The completed well was cased with 6-inch I.D. steel pipe to a depth of 240 feet. The lower 100 feet of casing was slotted to provide entrance of ground water to the well.

The well was test pumped at 160 gallons a minute for a period of 30 hours. The static water level was 36.33 feet below the top of the casing. The pumping level after 30 hours was 133 feet below the top of the casing, drawdown being 97 feet. The water was clear and appeared to be free of sediment and had excellent taste. Samples of the water were obtained for chemical-quality analysis given in the attached table.

It is my opinion that the well is capable of 150 gallons a minute sustained yield. The pump could be set at about the 200-foot depth below the top of the casing; this would allow ample space below the intake to serve as a sump for sediment that might be drawn into the well.

FOR THE DISTRICT CHIEF:

Chas. F. Keech

Chas. F. Keech

Attach. 2

Agate Test #1 Microscopic Analysis
H. M. DeGraw
July 10, 1967

Description	Depth, in feet From	To
Quaternary		
Holocene and Pleistocene		
Topsoil	0	1±
Sand, very fine to fine, predominantly very fine; slightly silty, noncalcareous	1±	7
Sand, very fine to fine, predominantly very fine; slightly silty, noncalcareous; trace of calcite	7	12
Sand, clean, very fine to fine with pieces of limestone, sandstone, and medium gravel; probably very slightly calcareous from 15-16 ft	12	16
Sand and gravel, predominantly very fine to medium; mostly gravel and pebbles (of limestone and calcareous cemented sandstone); predominantly very calcareous	16	20
Tertiary		
Miocene		
Arikaree Group		
Harrison Formation (?)		
Sand, predominantly very fine to fine; some medium to coarse with white soft lime; grayish-brown; non to very calcareous	20	23
Circulation sample		
Sandstone, predominantly very fine to fine with medium, light brownish-gray; lime-cemented and limestone, white, gray, some pebbles		23
Sand, predominantly very fine to fine, grayish-brown with soft white limestone pieces; predominantly noncalcareous.	23	28
As above	28	34.5
Interbedded (34.5-35.5 is sand)	34.5	43
Sand, predominantly very fine to fine, grayish-brown and hard white limestone layers, non to very calcareous		
Losing circulation and lost circulation at 41 ft.		
Circulation sample		
Limestone, white and sandstone, very fine to fine, silty, light-gray and soft sandstone, light-brown, very fine to fine, very slightly calcareous		43
Limestone, hard, sandy, very fine to fine, very light gray, very calcareous	43	46

	Depth, in feet	
	From	To
Harrison Formation (?)--Continued		
Sandstone, soft, predominantly very fine to fine, slightly calcareous (white limestone may be lag from above)	46	47
Interbedded, (47-48 hard, 48-50 soft), grayish-brown, sand and sandstone with lime cement; predominantly very fine to fine sand; slightly to very calcareous	47	50
Interbedded sand and sandstone; predominantly very fine to fine, grayish-brown; slightly silty; slightly to very calcareous	50	54
Monroe Creek Formation		
Hard sandstone, lime-cemented; predominantly very fine to fine; light-gray; very calcareous	54	58
Sand, very fine to fine; possibly slightly silty; slightly calcareous	58	62
Lost circulation		
No sample with 4" bit; changed to oversized 8" bit		
(Poor sample) Sand with white limestone pieces, predominantly very fine to fine with some medium and coarse, probably from cement plug; slightly calcareous	62	64.5
Circulation sample		
(Sand and gravel and pebbles from cement plug)		
Sandstone, very fine to fine, noncalcareous, light-brown..		
Sandstone, very fine to fine, moderately to very calcareous, very light gray; limestone, white, very calcareous		64.5
Sand, soft, brown, predominantly very fine to fine; trace of limy pieces; very slightly calcareous	64.5	67
Sandstone, hard, predominantly very fine to fine with white limy pieces, light brownish-gray, (poor sample ?); much medium to very coarse sand, which may be lag, slightly to very calcareous	67	68
Sand, soft, brown, predominantly very fine to fine, some coarser sand, probably from cement plug, non to very slightly calcareous	68	69
(Two samples) Interbedded, noncalcareous		
Sand, predominantly very fine to fine; brown; sandstone very fine to fine; non to medium calcareous	69	72
Sandstone, moderately hard, predominantly very fine to fine, some medium to coarse (lag ?); brown; slightly calcareous	72	75
Sand, soft; predominantly very fine to fine with trace of medium; trace of white limy sandstone; brown; non to slightly calcareous	75	78

	Depth, in feet From	To
Monroe Creek Formation--Continued		
Sandstone, hard; predominantly very fine to fine with some medium to coarse (lag ?); some white limy pieces; brown; slightly calcareous	78	80
Interbedded (80-81 and 82-83 soft; 81-82, hard) Sand and sandstone; predominantly very fine to fine, with trace of coarser, some moderately calcareous; cemented, brown, non to slightly calcareous	80	83
Sandstone, hard; predominantly very fine to fine, with trace of coarser sand; brown; some moderately calcareous, mostly non to slightly calcareous	83	85
Circulation sample		
Sandstone, very fine to fine; predominantly slightly silty; very light brownish-gray; slightly to moderately calcareous		85
Sandstone, hard, trace of medium to coarse; predominantly very fine to fine; slightly silty; light-brown; very calcareous	85	89.5
Sandstone; light brownish-gray and light brown; slightly to very calcareous	89.5	90
Sand; predominantly very fine to fine with dark minerals; slightly silty, trace of white limy sandstone; light-brown; noncalcareous	90	93
Interbedded. Sand; predominantly very fine to fine; slightly silty with black minerals; light-brown; noncalcareous; with white limestone pieces and sandstone, soft, lime-cemented, moderately calcareous, light brownish-gray	93	100
Sand, trace coarser, very fine to fine; predominantly noncalcareous; some white limy pieces with sandstone, moderately calcareous	100	104
Sand, soft, predominantly very fine to fine with trace of coarser; few lime-cemented pieces; light-brown; non-calcareous	104	111
Sandstone, hard, predominantly very fine to fine; slightly silty; light brownish-gray; moderately to very calcareous.	111	112
Sandstone, soft, as above, slightly silty	112	113
Sand, soft, as above, trace of coarser sand; slightly silty; light brownish-gray; moderately calcareous	113	125
Sand, predominantly very fine to fine, slightly silty with limy pieces (small sand size); light-brown; noncalcareous.	125	133
As above (limy pieces are probably in limestone layers	133	139
Sand, predominantly very fine with fine; moderately silty with limy pieces; light-brown; slightly calcareous	139	145
As above	145	153

	Depth, in feet	
	From	To
Monroe Creek Formation--Continued		
Sandstone, predominantly very fine to fine; slightly silty with hard white limestone pieces (layers); light-brown; noncalcareous	153	166
Sandstone, soft to hard; predominantly very fine to fine; moderately silty with hard white limestone pieces (layers); non to very calcareous; and sand, light-brown and white to very light-gray	166	187
(No sample), probably sandstone and limestone	187	193
Fracture zone		193
No samples collected	193	240
Total depth of test well		240

Samples are stored at the Conservation and Survey Division of the University of Nebraska, Room 113 Nebraska Hall, 901 North 17th Street, Lincoln, Nebr. 68508.

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

Analyses by Geological Survey, United States Department of the Interior

9-268 q

(parts per million)

Well Location 28N55W13cb 42°23'50"N Long. 103°41'41" Depth of sample, 240 ft.						
Date of collection	Aug. 8, 1967					
Silica (SiO_2)	56					
Iron (Fe)	--					
Manganese (Mn)	--					
Calcium (Ca)	36					
Magnesium (Mg)	7.9					
Sodium (Na)	13					
Potassium (K)	6.7					
Bicarbonate (HCO_3)	163					
Carbonate (CO_3)	0					
Sulfate (SO_4)	13					
Chloride (Cl)	3.1					
Fluoride (F)	.5					
Nitrate (NO_3)	13					
Dissolved solids						
Calculated	229					
Residue on evaporation at 180°C	248					
Hardness as $CaCO_3$	122					
Noncarbonate hardness as $CaCO_3$	0					
Alkalinity as $CaCO_3$	134					
Specific conductance (micromhos at 25°C)	332					
pH	7.3					
Color	5					
Boron	.03					
SAR	.5					

GPO 830-857

Appendix 3

Memo and responses;Water questions from Agate Fossil Beds National Monument,

May 9, 1986,

August 27, 1986,

October 10, 1986,

October 23, 1986

A memo from the park to the Water Resources Division raising several issues and concerns regarding the parks water resources and water rights. Several memos from the Water Resources Division respond to the questions and issues raised by the park.

L-54

UNITED STATES GOVERNMENT

memorandum

DATE: May 9, 1986

TO THE ATTENTION OF: Superintendent, Scotts Bluff and AGate Fossil Beds National Monuments

SUBJECT: Water Questions, Agate Fossil Beds National Monument

TO: Dick Ketcham

Enclosed are copies of most of what we have for water at Agate Fossil Beds which as you can see isn't much. We have had a number of questions regarding water and water resources at Agate. Among them are:

1. Since the National Park Service has taken over the area, great changes have occurred in the river environment. Large marsh areas have formed and in many places it is difficult to determine the main channel of the River. Are these changes the result of natural action, the removal of heavy cattle grazing in the area, termination of dredging, elimination of the impact of historic grazers, the result of periodic tumbleweed dams, or all of the above? What actions should we be taking in regard to the management of this small river?

2. What are the effects upon the river within the park originating outside the park? What is the quality of the river water? Is it heavily laden with pesticides? What is the effect of irrigation on levels of the river?

3. Do we in fact have any rights in regard to the water in the river or is our major guarantee of in stream flow predicated on the fact that there are senior water rights down stream?

4. We are often accused of causing great loss of irrigation water due to evaporation and transporation from the marsh area. Is this true?

5. Much of the upstream river area within the park boundaries lie within an area in which the Federal Government holds scenic easement only. We suspect from reading the easement that its terms would not prevent center pivot irrigation equipment from being installed in the park. If this is so should the easement be strengthened? What would the likely effect on the river be if such equipment were installed?

#6 What is the current status of surface versus ground water laws? Are we sufficiently protected to insure the future domestic water needs of the Monument?

Naturally we do not expect complete answers to these questions, but we do feel we have largely ignored the water resources within the Monument from management's standpoint. Any help your office can give us would be greatly appreciated.

Jerry Banta

OPTIONAL FORM NO. 10
(REV. 1-80)
GSA FPMR (41 CFR) 101-11.6
5010-114

☆ GPO : 1981 O - 341-526 (6587)

Stanley L. Ponce

August 27, 1986

L54 (479)
NWR/AGFO Water Rights

Memorandum

To: Jerry Banta, Superintendent, Agate Fossil Beds National Monument
Attn: John Kapier, Management Assistant

Through: Chief, Water Resources Division, Fort Collins

From: Chief, Water Rights Branch, Water Resources Division

Subject: Water Rights Issues in Agate Fossil Beds National Monument

Attached is the status sheet regarding water rights issues at Agate Fossil Beds National Monument. This form presents a concise statement of the issue and the action this office is taking to help solve questions raised by you and your staff.

Please contact myself or Scott Brown if you have any questions.

Stanley L. Ponce

Stanley L. Ponce

Attachment

cc: D. Scott Brown, WRB
Warren Hill, NWR
Michael Ruggiero, NWR

FNP:SPonce:cs:8/26/86:221-5341:20815brw.bit

Scott Brown SB

WATER RIGHTS BRANCH INFORMATION TRACKING SYSTEM

ISSUES AND CONCERNS

August 25, 1980

REGION: Rocky Mountain UNIT: AGFO DATE RECEIVED: 5 - 9 - 80 MODE: memorandum

CONTACTS:

Name Jerry Banta Title Superintendent, SCBL Phone 308/436-4340

Name John Rapier Title Management Assistant, AGFO Phone 308/668-2211

Name Mike Ruggiero Title Chief Scientist, NWR Phone 402/221-3431

WRB Lead Contact Scott Brown

LAST UPDATE: - -

ISSUE/CONCERN:

A few irrigators below the Agate Fossil Beds National Monument assert that the Park Service's management practices have created a condition whereby increased surface evaporation and transpiration have diminished the river's flow to the extent that their irrigation rights have been impacted.

Since the monument was created in 1965, cattle grazing and other historical land use practices have been excluded from the area. The riparian vegetation has changed significantly, causing changes in the Niobrara River's channel configuration. The river meanders approximately six miles through the monument.

The issue has raised other closely related questions concerning water rights and the monument's water resources. Discussions with the Superintendent and Management Assistant during field investigations by Dick Ketcham and Scott Brown, August 12-14, resolved a number of concerns expressed in the superintendent's memorandum of May 9. Those remaining in addition to the principal issue alluded to above are as follows.

1. Does the monument have a legitimate claim for instream flow rights?

2. To what extent are instream flows assured by the existence of senior appropriated water rights downstream?

3. Assuming that some one planning to irrigate lands might apply for a right to appropriate water immediately above the monument, what state process would be followed; what are the Park Service's rights with respect to due process; and what are the obligations and responsibilities of park managers and the Water Rights Branch, respectively?

4. What actions must be taken, if any, to assure that the water rights acquired by the Service when the Hoffman ranch was purchased are not declared abandoned by the state?

ACTION PLAN:

The Water Rights Branch will evaluate the historic trends of the river's flow and will research the Superintendent's questions concerning instream flow rights, due process, and the Hoffman water right. The following actions will be carried out.

1. Examine the hydrologic trend of the upper Niobrara River using gaging records of three stations:

   a. at the Wyoming - Nebraska border (06454000)
   b. at Agate Nebraska (06454100)
   c. above Box Butte Reservoir (06454500)

2. Seek legal advice from the Solicitor concerning the possibility of transferring an acquired right for irrigation to an instream flow right in Nebraska.

3. Obtain from the state of Nebraska a list of decreed water rights for the mainstem of the Niobrara River, listed according to priority.

4. Display the process for appropriating water in Nebraska; the process for objecting to applications for new water use permits; the responsibilities of park managers and the Water Rights Branch; and recommend actions needed, if any, to secure water rights that were acquired when the Hoffman ranch was purchased.

5. Draft report.

6. Review for draft report by Regional Park and WRB staff.

7. Submit final report

ACTION SCHEDULE

Action	Due Date	Completion Date	Responsible Person(s)
1	Sept. 15		Scott Brown
2	Sept. 15		Scott Brown
3	Sept. 20		Scott Brown
4	Sept. 20		Scott Brown
5	Sept. 25		Scott Brown
6	Sept. 29 - Oct. 10		WRB, MWR, AGFO/SCBL
7	Oct. 17		Stan Ponce

Richard Reicha
WRD-WSP
AGFO

October 10, 1986

L54 (479)
MWR/AGFO Water Rights

Memorandum

To: Superintendent, AGFO
Attn: John Rapier, Management Assistant

Through: Chief, Water Resources Div. Thomas W. Lucko

From: Chief, Water Rights Branch

Subject: Water Rights Issues in Agate Fossil Beds National Monument

This memorandum is our report to you concerning water right issues at Agate Fossil Beds National Monument.

The questions and concerns that were identified by our action plan of August 25, 1986, have been researched and we submit the following information and recommendations for your consideration.

Item 1

Examine the hydrologic trend of the upper Niobrara River using the gaging records of three stations:

a. at the Wyoming-Nebraska border (06454000);
b. at Agate, Nebraska (06454100); and
c. above Box Butte Reservoir (06454500).

RESULTS

Data from two of the above USGS gaging sites on the upper Niobrara River were gathered. The gage at Agate is located slightly above (upstream of) the monument, approximately 300 feet from the Highway 29 bridge. Records for this site are available from 1957 to the present. The gage above Box Butte Reservoir is located below (downstream of) the monument, approximately one mile upstream of the reservoir's high water line. Records for this station are available from 1947 to the present.

We gathered and examined the following types of data from each site:

a. normal monthly mean discharge;
b. cumulative monthly runoff;
c. normal annual mean discharge;
d. flow duration data;
e. lowest and highest mean discharge for selected numbers of consecutive days; and
f. mean daily discharge.

We recognized early that the data collected would not lend themselves to determining whether the river's flow has diminished measurably over the past two decades because of management practices within the monument. The gaging site above Box Butte Reservoir is located approximately 20 miles below the eastern boundary of the monument and between them are many unknown factors that affect the stream's flow regime.

Among the unknown factors are many that can produce significant and unpredictable changes to the flow regime. Examples include:

a) the timing and volume of irrigation withdrawals;

b) variable climatic conditions;

c) the contribution of ground water to surface flow or vice versa; and

d) impoundments on tributaries.

Those and probably other limiting factors preclude us from ascertaining with any degree of statistical certainty that a man-induced cause-effect relationship does or does not exist between land use practices within the monument and the flow regime of the Niobrara River.

Although it is our position that the limitations of these data do not allow a statistically valid conclusion to be drawn, our thorough analysis of the data and our understanding of the situation have led us to observe some trends and form some opinions. We will share them with the understanding that while they were derived through careful analysis, they are merely the observations and opinions of three professionals.

Please refer to Table 1, Mean Monthly Discharge of the Niobrara River at Two Gaging Stations (May-September). It compares each station's historical (pre-monument) mean monthly discharge with the mean monthly discharge of the periods 1967-1985 and 1976-1985. (Historical records for the station at Agate began in 1958; for the station above Box Butte Reservoir they began in 1947.)

The period 1976-1985 was selected because we assumed that the riparian vegetation within the monument would have established itself between 1965 and 1976. The months of May through September were separated from the remainder of the year because they coincide with the irrigation season and because evaporation and transpiration are greatest during those months.

Comparing historical discharge records (unbroken lines) with the discharge records of two recent periods (broken lines), we note the following observations.

a. May's flows during the two recent periods (1967-1985 and 1976-1985) have been slightly greater than those of the historical period, both above and below the monument.

i. May's average discharge at Agate was 13.9 cfs for the historical period (1958-1966), 14.78 cfs for the 1967-1985 period, and 14.84 for the 1976-1985 period.

ii. May's average discharge at the downstream site was 29.7 cfs for the historical period (1947-1966), 31.8 cfs for the 1967-1985, period, and 32.0 cfs for the 1976-1985 period.

b. June's historical flows were greater than those of the recent periods, both above and below the monument.

i. June's average discharge at Agate was 9.8 cfs for the 1976-1985 period, 10.4 cfs for the 1967-1985 period, and 10.8 cfs for the historical period. The differences constitute a 4-9 percent reduction of flow over the past 10- and 20-year periods.

ii. June's average discharge at the downstream site was 18.8 cfs for the 1976-1985 period, 20.9 cfs for the 1967-1985 period, and 26.6 cfs for the historical period (1947-1966). The differences constitute a 21-29 percent reduction of flow at the downstream site in June over the past 10- and 20-year periods.

c. July's historical flows were significantly greater than those of the recent periods, both above and below the monument.

i. July's average discharge at Agate was 7.6 cfs for the 1976-1985 period, 8.1 cfs for the 1967-1985 period, and 9.8 cfs for the historical period (1958-1966). The differences constitute a 17-22 percent reduction of flow above the monument in July over the past 10- and 20-year periods.

ii. July's average discharge at the downstream site was 14.1 cfs for the 1967-1985 period, 14.5 cfs for the 1976-1985 period, and 19.9 cfs for the historical period (1947-1966). The differences constitute a 27-29 percent reduction of flow at the downstream site in July over the past 10- and 20-year periods.

d. August's flows have shown remarkable stability from one period to another both above and below the monument.

i. August's average discharge at Agate was 7.80 cfs for the 1967-1985 period, 7.85 cfs for the historical period (1958-1966), and 7.86 for the 1976-1985 period.

ii. August's average discharge at the downstream site was 15.0 cfs for the 1967-1985 period, 16.2 cfs for the historical period (1947-1966), and 17.4 cfs for the 1976-1985 period. The difference between the 1976-1985 period and the historical period constitutes a seven percent increase of flow in August below the monument.

e. September's flows during the two recent periods (1967-1985 and 1976-1985) have been slightly greater than those of the historical period, both above and below the monument.

i. September's average discharge at Agate was 7.9 cfs for the historical period (1958-1966), 8.1 cfs for the 1976-1985 period, and 9.1 cfs for the 1967-1985 period.

ii. September's average discharge at the downstream site was 11.4 cfs for the historical period (1947-1966), 13.5 cfs for the 1967-1985 period and 14.1 cfs for the 1976-1985 period. The differences constitute an 18-24 percent increase of flow below the monument in September over the past 10- and 20-year periods.

Please refer also to Table 2: Summary of Mean Monthly Discharge and Percent Change from Historical Mean for Two Recent Periods of Two Gaging Stations.

TABLE 1. MEAN MONTHLY DISCHARGE OF THE NIOBRARA RIVER AT TWO GAGING STATIONS (MAY-SEPTEMBER)

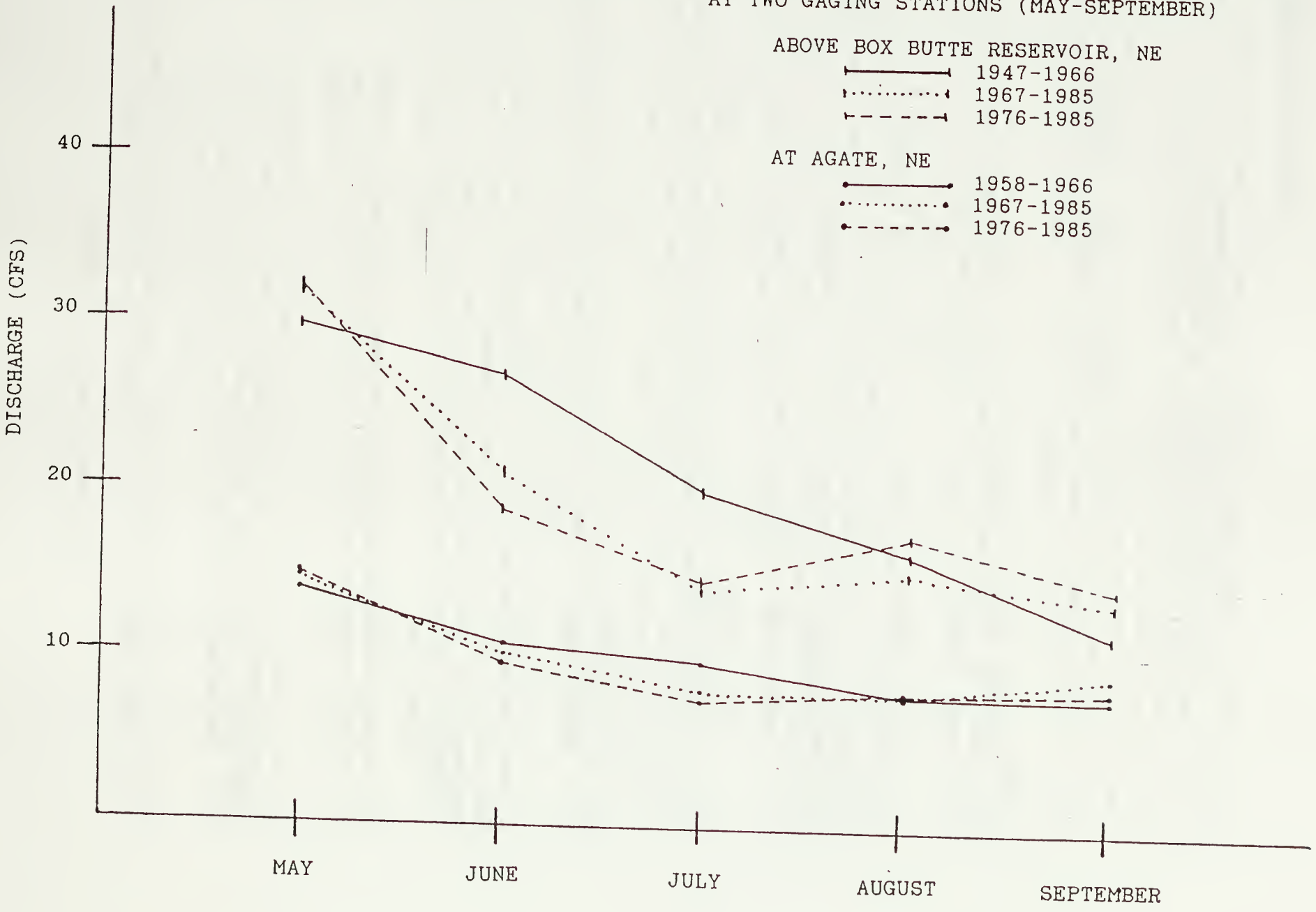


TABLE 2.
Summary of Mean Monthly Discharge
and Percent Change from Historical Mean
for Two Recent Periods at Two Gaging Stations

	Agate	Percent Change	Box Butte	Percent Change
MAY				
Historical	13.9		29.7	
1967 - 1985	14.8	+7 %	31.8	+7 %
1976 - 1985	14.8	+7 %	32.0	+8 %
JUNE				
Historical	10.8		26.6	
1967 - 1985	10.4	-4 %	20.9	-21 %
1976 - 1985	9.8	-9 %	18.8	-29 %
JULY				
Historical	9.8		19.9	
1967 - 1985	8.1	-17 %	14.1	-29 %
1976 - 1985	7.6	-22 %	14.5	-27 %
AUGUST				
Historical	7.9		16.2	
1967 - 1985	7.8	-1 %	15.0	-7 %
1976 - 1985	7.9	0	17.4	+7 %
SEPTEMBER				
Historical	7.9		11.4	
1967 - 1985	9.1	+15 %	13.5	+18 %
1976 - 1985	8.1	+3 %	14.1	+24 %

(Discharge values in CFS)

SUMMARY AND CONCLUSION

Flow data were obtained from two USGS gaging stations located above and below the Agate Fossil Beds National Monument. Much of the data was analyzed after being grouped into specified periods. Data that are representative of an historical period (pre-1966) and data that are representative of two subsequent periods (1967-1985 and 1976-1985) were compared; however, many intervening factors, which are largely unknown, impose severe limitations on the usefulness of these flow data for the purpose sought. We have, nevertheless, offered some observations and expressed our professional opinion with respect to the analysis. They are summarized as follows.

Mean monthly discharge records from the two gaging stations follow closely corresponding trends: Historical flows were greater than recent flows in June and July, but recent flows have been equal to or greater than historic flows in May, August, and September.

July's historical flows below the monument were 27 percent greater than flows recorded over the past 10 years. Such a reduction of flow is significant; however, it is important to note that July's historical flows above the monument (at Agate) were also significantly greater (22 percent) than those of the past 10 years. It is plausible that such a reduction of flow might have been perceived by irrigators below the monument, but a similar reduction occurred above the monument as well.

A comparison of August's flows at the two gaging sites is also noteworthy. August's flows for the 1976-1985 period below the monument were 7 percent greater than those of the historical period. Yet, August's flows above the monument show small variation over the entire period of record.

Finally, September's flows for the 1976-1985 below the monument were substantially greater (24 percent) than those of the historical period. Above the monument the change was not as great (3 percent).

The assertion that a diminishment of flow has occurred below the monument since 1966 and, further, that management practices within the monument have caused the flow to diminish, particularly in the late summer, is an assertion that ignores two points which we have emphasized and which are supported by the flow records. They are:

1. The reduction of flow that has occurred in June and July, since the monument was established, has occurred above the monument as well as below it.

2. A reduction of flow has not occurred in the late summer period, despite the fact that irrigation demand and evapotranspiration are often at their peak during that period. Recent August and September flows have been equal to or greater than historical flows, both above and below the monument.

We conclude that the data cannot support such an assertion and we would gladly share any of the additional data that we have gathered and examined.

Item 2

Seek legal advice from the Solicitor concerning the possibility of transferring an acquired right for irrigation to an instream flow right in Nebraska.

RESPONSE

This possibility was raised before it was learned that Nebraska has no provision for changing the purpose of a water right. Therefore, advice from the Solicitor's office regarding a change in use has not been sought. Instead, we refer you to the attached excerpts from Nebraska's surface water laws concerning instream appropriations (Section 46-2, 107-116, R.R.S., Nebr., 1985).

We suggest that serious consideration should be given to the possibility of operating within the framework of Nebraska's statutes to protect instream flows within the monument. If it is your desire to pursue an instream appropriation in the manner allowed by the state, the Water Rights Branch will initiate the process in cooperation with the Regional Office and the Solicitor's Office.

Item 3

Obtain from the State of Nebraska a list of decreed water rights for the mainstem of the Niobrara River, listed according to priority.

RESPONSE

The most recent listing of appropriations from the mainstem of the Niobrara River is found in the Nebraska Department of Water Resources' Forty-Fifth Biennial Report to the Governor. The report lists all appropriations recognized by Nebraska at the end of the 1983-1984 biennium. Below are listed all mainstem appropriations from the Wyoming-Nebraska border downstream to Box Butte Dam. They are not listed according to priority; however, priority dates are shown.

APPROPRIATOR	CARRIER	USE	PROVI GRANT (CFS)	DAT OF PRIO
Sioux County				
Ellicott Hereford Ranch, Inc.	Biglow-Seymour Canal	IR	1.20	06/08
Ray T. Dout Ranch & Cattle	Pumps	IR	1.20	06/08
Martin H. & W. Lucille Marshall	Johnson Canal	IR	2.09	05/01

Melvin R. & Klara M. Grote	Lakotah Canal	IR	5.85	10/01/1893
Six Bar Ranch, Inc. et al	Earnest Canal No. 2	IR	2.14	05/15/1891
Six Bar Ranch, Inc. et al	Earnest Canal No. 2	IR	1.46	03/24/1914
Six Bar Ranch, Inc. et al	Earnest Canal No. 1	IR	2.86	05/01/1885
Agate Springs Ranch, Inc.	McGinley-Stover N. Canal	IR	6.73	05/01/1887
Agate Springs Ranch, Inc.	McGinley-Stover S. Canal	IR	1.71	05/01/1890
Agate Springs Ranch, Inc.	McGinley-Stover N. & Cook Canal No. 2	IR	.71	05/31/1891
Agate Springs Ranch, Inc.	Cook South Canal No. 1	IR	2.31	05/31/1891
Agate Springs Ranch, Inc.	Pump	IR	1.48	05/01/1887
Agate Springs Ranch, Inc.	Pump	IR	.52	05/31/1891
Department of Interior	Pump	IR	1.24	12/07/1953
Oscar Skavdahl et al	Harris-Neece Canal	IR	8.57	07/01/1892
Morava, Morava, Morava & Snow, et al	Harris-Neece Canal	IR	7.27	07/11/1932
Morava, Morava, Morava & Snow, et al	Labelle Canal	IR	2.00	03/12/1895
Morava, Morava, Morava & Snow, et al	Labelle Canal	IR	3.14	07/03/1895
George E. Sandoz	Mettlen Canal	IR	4.90	04/27/1896
James L. Skavdahl	Mettlen Canal	IR	.75	12/18/1912
James L. Skavdahl	Mettlen Canal	IR	1.14	10/13/1931
James L. Skavdahl	Davison Canal	IR	.21	04/27/1922
Donald B. Armstrong	Bennett Canal	IR	3.45	12/18/1912
Donald B. Armstrong	Pump	IR	.59	06/20/1960
John J. & Patricia B. Manning	Moore Canal	IR	5.71	07/22/1895
Box Butte County				
Judy K. Prelle	Geo. Hitshew Canal	IR	6.00	02/17/1913

Judy K. Prelle	Pump	IR	.76	01/13/1966
Judy K. Prelle	Hitshew Canal No. 2	IR	.60	05/17/1951
Wilkins Ranch, Inc.	McLaughlin Canal	IR	7.14	05/01/1888
Hughes & Wilkins	Excelsior Canal	IR	2.86	05/15/1895
Hughes & Wohlers	Excelsior Canal	IR	1.92	03/28/1932
Hughes & Wohlers	Hughes Canal	IR	.57	05/31/1890
John K. Hughes	Hughes Canal	IR	.30	04/15/1894
Frank L. Dehaven	Pump	IR	6.15	10/19/1950
Dawes County				
Wyoming Fuel Company	Pump	MF		08/06/1984
Frances E. Chicoine et al	Pioneer Canals	IR	2.38	08/01/1887
Merle A. Danny & Lila P. Strawder	Pioneer Canal No. 2	IR	.78	03/08/1945
Merle A. Danny & Lila P. Strawder	Pioneer Canal No. 3	IR	.21	02/16/1950
Merle A. Danny & Lila P. Strawder	North Pioneer Canal	IR	.62	08/11/1952
Tomahawk Ranch & Cattle Co	Furman Canal	IR	.37	02/02/1894
Virginia Campbell	Pumps	IR	.53	01/27/1894
Virginia Campbell	Pump	IR	1.10	02/24/1953
Bureau of Reclamation	Box Butte Reservoir	ST	15000.00AF	03/06/1937
Bureau of Reclamation	Box Butte Reservoir	SS	32670.00AF	06/24/1941
Robert Delsing	Pump	IR	1.02	01/13/1981
Robert & Violet Lembke	Montague Canal	IR	.51	11/15/1965
Robert & Violet Lembke	Montague Canal	IR	1.76	03/31/1932
Myron P. & Elmada Lembke	Montague Canal	IR	.43	09/27/1900
Robert & Violet Lembke	Montague Canal	IR	.29	06/14/1937
Rachel D. Korsick	Montague Canal	IR	.60	07/11/1946
Leonard J. Kriz	Lighte Canal	IR	.71	04/19/1911

Charles L. Iodence	Lighte Canal	IR	1.47	01/24/189
Charles L. Iodence	Lighte Canal	IR	2.20	04/07/191
Charles L. Iodence	Lighte Canal	IR	.24	01/02/191
Charles L. Iodence	Lighte Canal	IR	.95	03/02/193
Charles L. Iodence	Lighte Canal	IR	.65	12/28/194
Duane E. Wildy	Potmesil Canal	IR	6.76	10/29/193
Duane E. Wildy	Potmesil Canal	IR	2.07	09/07/196.
Charles L. Iodence	Mirage Flats Canal	IR	2.00	03/02/193:
Bureau of Reclamation	Mirage Flats Canal	IR	135.78	01/25/193
Charles L. Iodence	Mirage Flats Canal	IR	1.46	02/11/193:
Bureau of Reclamation	Mirage Flats Canal	IR	30.76	05/18/194.
Bureau of Reclamation	Mirage Flats Canal	SI		08/05/195
Bureau of Reclamation	Mirage Flats Canal	SI		08/05/195

Note: IR-Irrigation, MF-Manufacturing, ST-Storage, SS-Supplemental storage, SI- Supplemental irrigation

Mr. Robert Bishop, Chief of the Operations Branch, Nebraska Department of Water Resources, stated in a recent telephone conversation that Box Butte Reservoir has not filled for more than 20 years. If that is the case, the Bureau of Reclamation's storage and supplemental storage rights of 15,000 acre-feet per year (3/6/37) and 32,670 acre feet per year (6/24/41), and probably other rights as well, are not being satisfied.

It is noteworthy that in 1962 Nebraska and Wyoming apportioned the waters of the upper Niabrara River. The terms of the apportionment are contained in the attached compact.

Item 4

Display the process for appropriating water in Nebraska; the process for objecting to applications for new water use permits; the responsibilities of park managers and the Water Rights Branch; and recommend actions needed, if any, to secure water rights that were acquired when the Hoffman ranch was purchased.

RESPONSE

Nebraska law gives the Department of Water Resources jurisdiction over all water right matters except those specifically limited by statute (Section 46-209, R.R.S., Nebr., 1943). In short, the Director of the Department has broad ranging authority, particularly with respect to applications for new surface water permits.

Unlike many neighboring states, Nebraska does not automatically provide for public notice when applications for new appropriations are being processed. With few exceptions, applicants receive their permit to put water to beneficial use within 30 days of the Department's receipt of an application and fee (currently $200).

There is currently in place a moratorium against new appropriations on only two streams in Nebraska: Pumpkinseed Creek (a tributary of the North Platte River) and Lodgepole Creek (a tributary of the South Platte River). If the Department receives an application for water in any other basin, and if the application is complete, then Nebraska law directs the Department to allow the use to be perfected. Section 46-235, R.R.S., Nebr., 1943 reads:

> "the Department of Water Resources shall approve the same, by endorsement thereon, and shall make a record of such endorsement in some proper manner in its office and return the same so endorsed to the applicant, who shall, on receipt thereof be authorized to proceed with the work and to take such measures as may be necessary to perfect such application into an appropriation."

The same statute, however, gives the Department authority to impose certain restrictions on the appropriation.

> "The Department may, upon examination of such application, endorse it approved for a less period of time for perfecting the proposed appropriation, or for a less amount of water, or for a less amount of land than applied for. The Department may also impose such other reasonable conditions as it deems appropriate to protect the public interest (Section 46-235, R.R.S., Nebr., 1943).

One such condition that is routinely imposed upon new appropriations is that the right to divert is subject to senior appropriations being satisfied first. If at any time an appropriator fails to receive water to which he feels he is entitled, he notifies the Department of Water Resources and the Department conducts a field inspection. Upon finding that a senior appropriator's rights are not being satisfied, the Department issues notices, or closing orders, to junior appropriators to discontinue their diversions. When conditions permit junior appropriators to resume their diversions, the Department follows with another notice suspending the earlier order.

In the absence of a public notice provision for new appropriations, our only recourse, in the event the Service's rights are not being satisfied because of the actions of junior appropriators, is to follow the procedure described above. In view of existing conditions on the upper Niobrara River, however, we can expect that in most years the state will continue to send notices to AGFO to stop diverting for a portion of the irrigation season because more senior appropriators downstream require the water.

According to one official in the Department of Water Resources, Robert Bishop, Chief, Operations Branch, water supply conditions on the upper Niobrara are such that applications for new water uses over the past few years have been very few. Apparently, everyone is aware of the fact that already the stream is heavily appropriated and virtually every summer closing orders will be sent out to protect the senior appropriators.

Finally, Nebraska law does not provide for a change in the purpose of a water use. Originally, we had discussed the possibility of effecting a change for a portion of the irrigation right that was acquired with the Hoffman ranch. At that time, we were unaware of the fact that Nebraska has no provision for change, other than for a change in the point of diversion or the place of use. Therefore, we recommend that you continue the practice of pumping and reporting to the state each year, as before.

Copies of Nebraska's Rules for Surface Water and Rules for Ground Water are enclosed. Also enclosed is a copy of Section 46-229.05, R.R.S., Nebr., 1943, which you may want to read.

If you or your staff have any questions, please contact Scott Brown or myself. We look forward to hearing from you regarding the possibility of applying to Nebraska for an instream appropriation.

Stanley L. Ponce

Stanley L. Ponce

Attachments

cc: D. Scott Brown, WRB-WRD (w/ att)
Richard Ketcham, WSB-WRD (w/ att)
Warren Hill, MWR (w/att)
Michael Ruggiero, MWR (w/att)

FNP:DSBrown:cs:pml:221-5341:9/22/86:20922brw.ag

United States Department of the Interior
NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
301 SOUTH HOWES ST., ROOM 343
FT. COLLINS, COLORADO 80521

IN REPLY REFER TO:

October 23, 1986

L54 (479)
AGFO/General

Memorandum

Thomas W. Lucke 10/29/86

To: Chief, Water Resources Division

Through: Chief, Water Services Branch

From: Hydraulic Engineer

Subject: Water questions - Agate Fossil Beds National Monument.

By memorandum of May 9, 1986 the Superintendent of Scotts Bluff expressed concern for the water resources of the area in the form of 6 questions. The following material reiterates the questions and provides answers. In that some of the questions involve broad and/or complicated topics, our answers may be considered as preliminary comments. Further investigations or projects will be necessary to provide quantified answers.

Question 1.

Since the National Park Service has taken over the area, great changes have occurred in the river environment. Large marsh areas have formed and in many places it is difficult to determine the main channel of the River. Are these changes the result of natural action, the removal of heavy cattle grazing in the area, termination of dredging, elimination of the impact of historic grazers, the result of periodic tumbleweed dams, or all of the above? What actions should we be taking in regard to the management of this small river.

Answer

This question was partly answered in our memorandum of October 10, from Chief, Water Rights by his flow analysis of gaging stations and partly in following answers to your other questions.

Question 2.

What are the effects upon the river within the park originating outside the park? What is the quality of the river water? Is is heavily laden with pesticides? What is the effect of irrigation on levels of the river?

Answer

The chemical quality of the Niobrara is good. Further downstream at Box Butts there are no unusally high constituents of concern (water quality analysis attached) The dissolved oxygen is near saturation and showing only moderate biological pollution. We nor the USGS have any pesticide information on the Niobrara near Agate. Therefore your closest and best source of information is the Fish and Wildlife Service in Pierre, South Dakota. We have discussed this question with Mr. Chuck Sowards, Comm. 605-224-8693, (FTS) 782-5228, FWS. He felt the best organism to test would be fish, however, sediments might also be useful. He indicated that testing the water would probably not provide adequate analysis due to the volitle nature of many pesticides. We suggest your checking of feed stores to determine what chemicals are being sold/used. This information can then be used to greatly reduce the number of analysis required for an adequate test. Analysis can be done by FWS, each sample will cost about $175.00. Samples (fish or sediment) should be collected in midsummer. We have a list of legal heracides and pesticides in eastern Wyoming and will forward them to you if you wish, the number exceeds 8,500 different products.

Question 3.

Do we in fact have any rights in regard to the water in the river or is our major guarantee of instream flow predicted on the fact that there are senior water rights downstream?

Answer

Our memorandum of October 10, dealt with water rights on the Niobrara from Wyoming to Box Butte dam. There are 61 appropriations and 55 of them are senior to our Hoffman Pump right. This is equal to 90%. More than 98% of the senior rights are for irrigation. The total amount of water already allotted is at least seven times the flow of the Niobrara at Agate in Sioux County alone. This is true of many basins including the Colorado in which Indian water rights alone are three times the flow of the river.

Surface waters can and have been appropriated. Our acquired Hoffman Pump right to water from the Niobrara will have to stand on its own merit with other rights to the river water downstream. The downstream water rights may be our best protection of instream flow.

Question 4.

We are often accused of causing great loss of irrigation water due to evaporation and transportation from the marsh area. Is this true?

Answer

We would have to know the time that the land is inundated. By assuming the entire area of the Monument is flooded from January to June from terrace to terrace, it is possible to lose four percent of the total river flow by evaporation from snow, ice and water. Evaporation is decreased by snow and ice as the vapor pressure on frozen surfaces is lower than on water. With a snow or ice termperature of 30°F and a dewpoint of 20°F the evaporation rate is only one-fifth that from a water surface at 80°F when the dewpoint is 70°F, with the same windspeed assumed in both cases. Based upon the above considerations/factors, it appears that the loss of water from the park as evaporation is negligible.

Question 5.

Much of the upstream river area within the park boundaries lie within an area in which the Federal Government holds scenic easement only. We suspect from reading the easement that its terms would not prevent center pivot irrigation equipment from being installed in the park. If this is so, should the easement be strengthened? What would the likely effect on the river be if such equipment were installed?

Answer

A legal opinion regarding the application of center pivot irrigation within the Monument has been requested of the solicitor. This response is expected in the near future.

The USGS, Water Resources Investigation 80-43 by R.A. Engherg states that most of the Niobrara flow in the sand hills is due to groundwater seepage, not from runoff. However, we would expect some of the flow infiltrates to recharge the Ogallala aquifer, at least in some areas. This indicates that during the irrigation season, groundwater withdrawal would definantly effect the flow of the Niobrara, especially if the wells were in close proximity to the river. The drawdown of the irrigation wells will cause groundwater to flow away from the river and into the well.

Question 6

What is the current status of surface versus groundwater laws? Are we sufficiently protected to insure the future domestic water needs of the Monument?

Answer

There is no groundwater law in Nebraska except for irrigation wells which must be spaced in accordance with State regulations. It is our opinion that park domestic systems are safe for the forseeable future. We presently have 216,000 gallons of water a day available from our headquarters supply well. New potable water sources can be developed by drilling additional well(s) at any location on the Monument that is Federally owned.

Richard A. Ketcham

Richard Ketcham

06454500 Niobrara River above Box Butte Reservoir, Nebr.

Location.--Lat 42°27'35", long 103°10'15", in NE¼ sec. 27, T.29 N., R.50 W., Dawes County, Hydrologic Unit 10150002, on right bank 1 mi upstream from high-water line of Box Butte Reservoir and 6 mi east of Marsland.

Drainage area.--1,400 mi^2, approximately.

Period of record.--July 1975 to current year.

Statistical data for selected chemical constituents

Constituent	Units	No. of measurements	Maximum	Minimum	Mean	Median	Standard deviation	Ninetieth percentile	Tenth percentile
Specific conductance	umho/cm	27	472	358	413	414	28	450	370
Dissolved solids, residue	mg/L	17	325	263	286	282	17	310	270
Dissolved solids, sum	mg/L	9	300	266	281	--------	13	----------	
Hardness as $CaCO_3$	mg/L	8	180	150	160	--------	12	----------	
Calcium, dissolved	mg/L	8	54	45	49	--------	3.8	----------	
Magnesium, dissolved	mg/L	8	10	8.1	9.3	--------	0.7	----------	
Sodium, dissolved	mg/L	8	37	22	26	--------	4.6	----------	
Potassium, dissolved	mg/L	8	8.7	6.3	7.4	--------	1.0	----------	
Bicarbonate ion	mg/L	8	270	210	243	--------	21	----------	
Sulfate, dissolved	mg/L	8	33	11	16	--------	7.1	----------	
Chloride, dissolved	mg/L	25	8.3	3.5	5.3	4.9	1.2	7.1	3.9
Fluoride, dissolved	mg/L	9	0.8	0.6	0.7	--------	0.07	----------	
Silica, dissolved	mg/L	8	52	39	47	--------	4.2	----------	
Boron, dissolved	mg/L	8	160	40	68	--------	38	----------	
Iron, dissolved	ug/L	8	180	0	46	--------	58	----------	
Manganese, dissolved	ug/L	8	200	5.0	46	--------	64	----------	
Nitrite + nitrate as N, dissolved	mg/L	----------							
Nitrate as N, dissolved	mg/L	----------							
Nitrate as NO_3, dissolved	mg/L	----------							
Ammonia N, total	mg/L	28	0.07	0.00	0.02	0.02	0.02	0.05	0.00
Organic N, total	mg/L	28	0.81	0.15	0.43	0.38	0.19	0.71	0.21
Phosphorus, total	mg/L	28	0.12	0.00	0.04	0.04	0.03	0.09	0.01
Phosphorus, dissolved	mg/L	20	0.08	0.00	0.02	0.02	0.02	0.05	0.00
Fecal coliform	col/100 ml	15	1,800	1	-------	66	----------	465	0
Fecal streptococci	col/100 ml	23	4,200	9	-------	56	----------	660	16
Oxygen, dissolved	mg/L	28	16.5	8.2	-------	10.0	----------	13.0	8.5
Biochemical oxygen demand (5-day)	mg/L	26	9.4	0.6	2.9	2.5	1.9	5.2	1.1
pH	pH units	28	7.8	7.1	7.4	7.4	0.2	7.7	7.2
Color	Co - Pt units	9	25	3	14	--------	8	----------	

06454500 Niobrara River above Box Butte Reservoir, Nebr.--Continued

Results of regression analyses relating concentrations of selected chemical constituents to specific conductance (SpC)

Dissolved constituents (mg/L)	No. of measurements	Regression equation	Correlation coefficient	Percent explained variance	Standard error of estimate (mg/L)
Dissolved solids, residue (RDS)	17	RDS = 0.110(SpC)+ 240.947	*0.17	3.0	17
Dissolved solids, sum (SDS)	----	----	----	----	----
Hardness as $CaCO_3$ (TH)	----	----	----	----	----
Calcium (Ca)	----	----	----	----	----
Magnesium (Mg)	----	----	----	----	----
Sodium (Na)	----	----	----	----	----
Potassium (K)	----	----	----	----	----
Bicarbonate (HCO_3)	----	----	----	----	----
Sulfate (SO_4)	----	----	----	----	----
Chloride (Cl)	25	Cl = 0.003(SpC)+ 4.187	* .06	0.42	1.2
Silica (Si)	----	----	----	----	----
Nitrite + Nitrate as N (NO_2-NO_3)	----	----	----	----	----

* Not significant at 95 percent confidence level; the regression equation should not be used to predict the concentration of the dependent variable.

Results of regression analyses relating specific conductance to water discharge (Q)

No. of measurements	Water discharge (ft^3/s) Maximum	Water discharge (ft^3/s) Minimum	Regression equation	Correlation coefficient	Percent explained variance	Standard error of estimate Log units	Standard error of estimate Percent
27	86	6.6	$SpC = 406Q^{0.00508}$	*0.04	0.20	0.031	7.1

*Not significant at 95 percent confidence level; the regression equation should not be used to predict the concentration of the dependent variable.

United States Department of the Interior
OFFICE OF THE SOLICITOR
OFFICE OF THE REGIONAL SOLICITOR
P.O. BOX 25007
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

→ Dick Ketcham
L-54
Agate

October 23, 1986

NPS.RM.1048

Memorandum

To: Regional Director, Midwest Region, National Park Service, Omaha, Nebraska

From: Regional Solicitor, Rocky Mountain Region

Subject: Potential Change in Land Usage at Agate Fossil Beds National Monument

The superintendent of Agate Fossil Beds National Monument has expressed concern regarding the imminent possibility of visual obstruction to the monument by the installation of center-pivot irrigation systems on properties within the monument in which the NPS (National Park Service) has only an easement. Up to now, no problem has arisen, as the land covered by these easements has been used for cattle grazing, a compatible use.

The cattle business in western Nebraska is now in financial distress, and many local cattle ranchers have converted their land to farming, using center-pivot irrigation systems in their operations. The superintendent anticipates that the easement owners may soon request permission, or independently proceed, to establish such systems, and he believes that the systems would be inimical to monument purposes because of their height and size.

You have asked whether the terms of the easement would allow the landowners to install center-pivot irrigation systems.

The United States acquired the subject easements by condemnation. The landowners reserved the following rights in the condemnation instruments:

> Ingress and egress across lands . . . for the purpose of maintenance and repair and use of an irrigation system, a portion of the ditches of which pass through said tract;

the United States received:

> . . . an easement in and right in perpetuity to restrict the future use and development of [the subject tract] . . . ;

and the landowners were expressly refrained from the following:

> b. Erecting or building any structures on said land, except as may be authorized in writing by the Secretary of the Interior . . . .

However, the instruments also provided as follows:

> g. [Landowners] . . . shall not be precluded hereby from maintaining and/or constructing any irrigation system done in conformity with good husbandry practices and in accordance with other provisions of this instrument.

Based upon the language in subclause g. above, the landowner has the right to construct an irrigation system done in conformity with good husbandry practices. Center-pivot irrigation meets this criterion. However, because that provision is qualified by the phrase "in accordance with other provisions of this instrument," it is subject to subclause b., above, which refrain the landowner from erecting or constructing a structure on his land without the written authorization of the Secretary of the Interior.

The purposes of the national monument expressed in the authorizing act are as follows:

> . . . to preserve for the benefit and enjoyment of present and future generations the outstanding paleontological sites . . . and nearly related geological phenomena . . . and for the display and interpretation of the scientific specimens uncovered at such sites, and to facilitate the protection and exhibition of a valuable collection of Indian artifacts and relics . . . . (Act of June 5, 1965, 79 Stat. 123.)

A center-pivot irrigation system installed on easement land could interfere with the display and interpretation of scientific specimens at sites on the monument. Such would conflict with the purposes for which the monument was authorized.

It is, therefore, my opinion that the landowner must obtain the prior written approval of the Secretary to install or erect a center-pivot irrigation system on easement land. This opinion is based both upon the language in the condemnation instrument and upon the express purpose of the national monument as provided in the authorizing legislation.

Ralph O. Canaday

Ralph O. Canaday
For the Regional Solicitor
Rocky Mountain Region

Appendix 4

Drillers logs and well driller's report for the domestic supply well and the fire supply well constructed in October 1992 at the maintenance area

Information regarding construction and testing of the wells.

Depth		Description
From	To	
0	5	LOOSE SANDY SOIL MATERIAL
5	10	SANDY SOIL MATERIAL
10	17	LOOSE LIMEROCK & LOOSE SAND TO SOFT SANDSTONE
17	20	LAYERS SILTY SAND & BURIED LAYER BLACK SOIL
20	40	LAYERS LIMESTONE BROWN SILTY SANDSTONE TR GRAVEL
40	60	LOOSE ALLUVIAL LIMEROCK SANDSTONE & GRAVEL
60	80	FINE GRAY ARIKAREE SANDSTONE WITH LIMESTONE LEDGES
80	100	FINE GRAY ARIKAREE SS WITH HARD LIMESTONE LEDGES
100	120	FINE GRAY ARIKAREE SS WITH FIRM LIMESTONE LEDGES
120	140	FINE BROWN TO GRAY SANDSTONE SOME LIMESTONE
140	160	FINE BROWN TO GRAY FIRM SANDSTONE SOME LIMESTONE
160	180	FINE BROWN SILTY SS WITH SOME LIMESTONE STREAKS

Geologic log of domestic supply well near the maintenance building at Agate Fossil Beds National Monument

Nebraska DNR Registration Number G-079953, Well ID 88610

Well constructed October 1992

Depth		Description
From	To	
0	5	LOOSE SANDY SOIL MATERIAL
5	15	LOOSE SAND & TRACE BROWN SANDSTONE
15	30	LOOSE SAND & SOME LIMESTONE ROCK
30	47	LOOSE ALLUVIAL GRAVEL SANDSTONE & LIMESTONE
47	105	ARIKAREE FINE CLEAN SS WITH LIMESTONE LEDGES
105	135	SOFT BROWN SANDSTONE & SOME SOFT LIMESTONE ROCK
135	180	SOFT BROWN SANDSTONE SOME FINE SILTY SANDSTONE

Geologic log of fire supply well near the maintenance building at Agate Fossil Beds National Monument

Nebraska DNR Registration Number G-079952, Well ID 88609

Well constructed October 1992

WATER VAULT DETAIL

NO SCALE

1
M6

IELSON WELLS, Inc.

:34 — Box 6A

liance, Nebraska 69301

one (308) 762-1592

Oct. 29, 1992

TEST PUMPING REPORT

TO: Robert Hamann
Contracting Officer's Representative

FROM: Glenn Nelson
Nelson Wells, Inc.

REL: Agate Fossil Beds National Monument
Well Drilling Contract Order No. 1443PX600092464

The following data provides the test pumping results on the 6" and 10" cased wells for the project records. The results indicate that the well design has been excellent and that the additional screen recommendation seems to have been justified. The ideal pumping condition exists when the production level needed can be produced without reducing the pumping level into the screened portion of the well, as drawdown into the screen may lead to aerated water production.

The screen placement in both wells starts at 90' below the surface. In the 6" well the yield at the screen level is about 138 gallons per minute. The yield in the 10" well was 396 gallons per minute at a pumping level of 76', that was the highest production point tested.

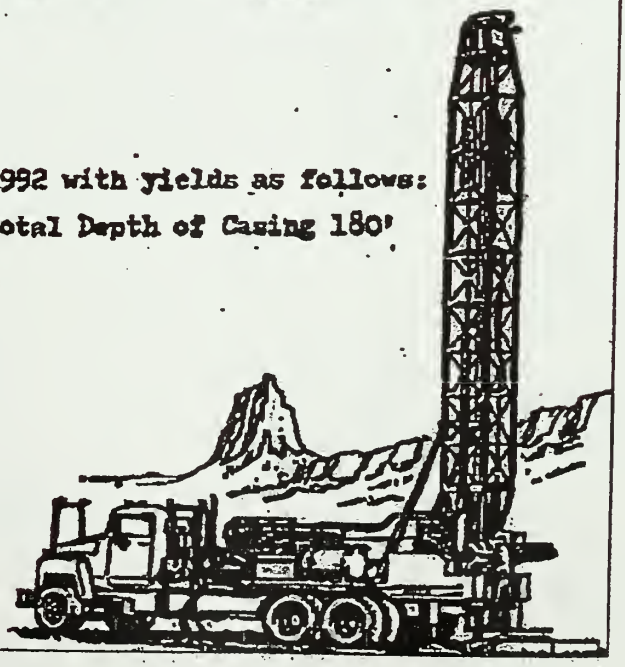
The water is very clean but may yield minor, very fine sand when the wells are started, that subsides quite rapidly, due to the fact we did not use a check valve during test pumping to aid in getting sand removed by surging actions.

The 6" well was pumped for 14 hours on Oct. 8th and 9th, 1992 with yields as listed below:

Static water level . . . . . 27'6" Total Depth of Casing 180'
80 Gallons Per Minute . . . 57'
106 Gallons Per Minute . . . 72'
131 Gallons Per Minute . . . 85'
162 Gallons Per Minute . . 105'
187 Gallons Per Minute . . 120'

The 10" well was pumped for 6 hours on Oct. 23, 1992 with yields as follows:

Static water level . . . . . 26' Total Depth of Casing 180'
170 Gallons Per Minute . . . 55'
209 Gallons Per Minute . . . 57'
241 Gallons Per Minute . . . 62'
291 Gallons Per Minute . . . 67'
350 Gallons Per Minute . . . 72'
396 Gallons Per Minute . . . 76'



Nationally Certified Drillers
& Pump Installers

Appendix 5

Memo, Flow measurement of the Niobrara River within Agate Fossil Beds National Monument, August 8, 2002

Description of a seepage study on the Niobrara River through the park to attempt to locate reaches of gain or loss of streamflow.

United States Department of the Interior

NATIONAL PARK SERVICE

Agate Fossil Beds National Monument
301 River Road, Harrison, NE 69346-2734
Ph. 308-668-2211 Fax 308-668-2318 http://www.nps.gov/agfo

IN REPLY REFER TO:

N16C (AGFO)

August 8, 2002

Memorandum

To: File

From: Kimberly Howard, AGFO Biological Technician Kimberly M Howard

Subject: Flow Measurement of the Niobrara River within Agate Fossil Beds National Monument.

Summary: Flow measurements of the Niobrara River within the park boundaries were taken July 25, 26 and 29 and August 7, 2002, by Kim Howard, Lil Morava (AGFO VUA) and Nick Schonek (AGFO VIP.) The purpose of this was to establish locations of springs and seeps as well as become familiar with the flow patterns of this reach of the Niobrara River. The flow was measured with a sag tape method starting from the left bank. A Global Water Meter was used to measure velocity in decameters per second. All other measurements were made in meters. For a complete procedure see page 2.

Frequency of Measure: The first flow measurement was taken at the staff gauge near the Agate Springs Ranch headquarters bridge and is referred to as "ranch" in the spreadsheets. Flows were then taken after a seep or spring or every ¼ mile straight distance. See the attached map for distribution. Each location was GPSed and assigned a sequential number (F2, F3, F4 .....). If the flow was near another park feature, this was noted on the data sheet but not in the GPS.

Data: The data were entered into Excel. Discharge was calculated for each cell (depth X cell width X velocity) giving cubic decameters per second. These were added up for each flow to give the total per location and is saved in the worksheet labeled "Raw Data." A second worksheet was created, labeled "Summary of Data," which summarizes the data on to one page and provides additional information. The fields for the summary sheet are as follows:

Site: name of site in GPS and ArcView layer
Date: Date the flow was collected, times of flow collection are in the ArcView layer.
m2/sec: The discharge was converted to cubic meters per second (cms) from the totals
cfs: cms were converted to cubic feet per second (cfs) using the correction factor of one cubic meter/second = 35.314666 cubic foot/second.
Stage: Stage reading at time of flow, derived from gauge graph at Agate Springs Ranch
Corr Stage: Used the correction factor of +0.13 cfs as recommended by Dan Hitch of the USGS Nebraska District at North Platte, who measured Niobrara River flow and adjusted the gauge on 8/7/02.
Flow Curve: Flow derived from rating curve using the corrected stage, curve develop 10-01-1986.
Change from Previous:
Cfs: discharge in cfs minus previous discharge in cfs
Stage: Change in stage readings from previous discharge location
Reason: known reason for significant change.

Comments: The last rating table for the gauge was developed in 1986, and the last published record for the gauge was in 1991. Since then the paper has been changed by park staff and a record of stage kept at the park office.

Procedure:

1. Measure distance from left to right bank, leave the tape staked across the channel, Align the 1 meter mark with the left wetter edge.

2. Find distance to right wetted edge, remember to subtract 1 m from tape distance.
3. Divide the distance between wetted edge by ten, so if the wetter edge was 2 meters, one cell would be 0.2 m.
4. Divide the unit in halve to find the middle of the cell, so 0.2 m would be 0.1 m, this will be your first measuring point.
5. Find depth and record at the first point then multiply depth by 0.60 and take flow at that depth. So if the depth was 0.5 m, flow would be taken at a depth of 0.3 m. Record average flow after 40 seconds.
6. Repeat depth and flow in the middle of each cell, in the example used above this would mean add 0.2m to 0.1m to take the measurement at 0.3 m. you should have a total of 10 measurements.

Finding discharge from measurements
The flow measurements can be should be entered into a spreadsheet and calculations done using functions. I will set up the spreadsheet, but this is to give an idea of the calculation made.
Formulas: Discharge (Q) = Area (A) X Velocity (V)
$Q = m^3$ / second, $A = m^2$, V = m / second
A = cell width times water depth, V = reading of flow meter.

Conclusions
The 2002 flow measurements taken indicate not much water is gained by the Niobrara River through the park. Only two springs were positively identified and several seep areas. Measurements were taken in a drought year, in the middle of summer with irrigation in progress, which all affect the measurements greatly. If flows were taken in the fall or spring, with no irrigation in progress upstream, measurements would be more valuable and comparable. Six weeks after the survey, I noted several possible springs and noticed more water in ponds that are groundwater fed, indicating there are probably more springs but they were not active at the time of survey.

To further evaluate flow in the river, several suggestion have been discussed. The gauging station at the ranch needs to have a new rating table developed for converting stage into flow. It might also be possible to use the culvert at the ranch bridge as a weir to develop a rating curve for water height compared to flow. The web site http://www.albemarle.org/engineer/personnel/channelflowhelp.html provides information in this topic. And finally, if further measurements flow measurements are taken using the sag tape method (the one described in the main text of this memo), the Dan Hitch of the USGS recommends using 20 cells instead of ten. With higher flows this will be easier, as the river will be wider.

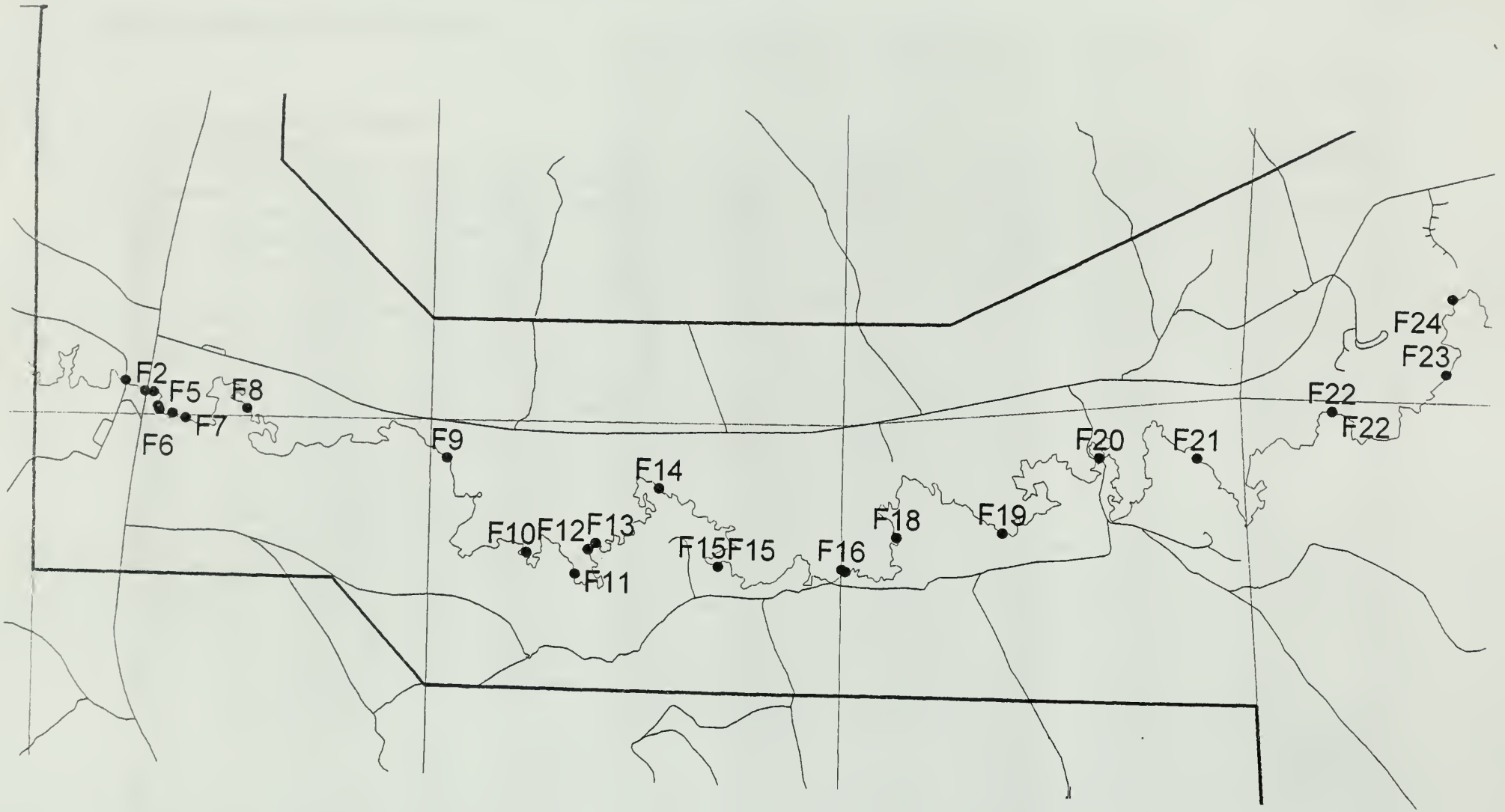
Attachments:
Summary of Niobrara Flow Data
Flow Data Collection Points Map

Site	Date	probe	m2/sec	cfs	Stage	Corr Stage	Flow Curve	Change from Prev		reason
Ranch	7/25/02	1.65	0.16	5.82	2.78	2.91	6.35	in cfs	stage	AM
Ranch	7/25/02	1.24	0.12	4.36	2.68	2.81	5.14	0	0	PM
Ranch	7/17/02	1.01	0.10	3.58	2.38	2.51	2.23	0	0	
Ranch	8/6/02	1.15	0.11	4.04	2.54	2.67	3.65	0	0	
Spring1	7/25/02	0.03	0.00	0.11	2.72	2.85	5.61	0	0	
F2	7/25/02	1.64	0.16	5.80	2.70	2.83	5.37	-0.02	-0.08	irrigation
F3	7/25/02	1.61	0.16	5.69	2.66	2.79	4.91	-0.11	-0.04	irrigation
F4	7/25/02	1.54	0.15	5.45	2.65	2.78	4.80	-0.23	-0.01	irrigation
F5	7/25/02	1.61	0.16	5.68	2.65	2.78	4.80	0.22	0.00	
F6	7/25/02	1.70	0.17	5.99	2.65	2.78	4.80	0.32	0.00	
F7	7/25/02	1.51	0.15	5.34	2.65	2.78	4.80	-0.65	0.00	
F8	7/25/02	1.29	0.13	4.54	2.65	2.78	4.80	-0.81	0.00	
F9	7/25/02	1.65	0.17	5.83	2.65	2.78	4.80	1.29	0.00	silty bottom
F10	7/25/02	1.60	0.16	5.66	2.65	2.78	4.80	-0.17	0.00	
F10	7/26/02	1.93	0.19	6.80	2.79	2.92	6.47	1.14	0.14	new day
F11	7/26/02	2.04	0.20	7.21	2.97	3.10	8.93	0.41	0.18	
F12	7/26/02	2.31	0.23	8.16	2.74	2.87	5.85	0.95	-0.23	
F13	7/26/02	1.57	0.16	5.56	2.73	2.86	5.73	-2.61	-0.01	
F14	7/27/02	1.76	0.18	6.21	2.73	2.86	5.73	0.65	0.00	
F15	7/27/02	1.86	0.19	6.57	2.72	2.85	5.61	0.36	-0.01	
F15	7/29/02	1.49	0.15	5.26	2.64	2.77	4.69	-1.31	-0.08	new day
F16	7/29/02	1.56	0.16	5.52	2.63	2.76	4.58	0.25	-0.01	
F17	7/29/02	1.50	0.15	5.30	2.62	2.75	4.47	-0.22	-0.01	
F18	7/29/02	1.43	0.14	5.05	2.61	2.74	4.37	-0.25	-0.01	irrigation
F19	7/29/02	1.62	0.16	5.73	2.61	2.74	4.37	0.68	0.00	
F20	7/29/02	1.39	0.14	4.90	2.60	2.73	4.26	-0.82	-0.01	
F21	7/29/02	1.32	0.13	4.67	2.60	2.73	4.26	-0.24	0.00	
F22	7/29/02	1.44	0.14	5.09	2.60	2.73	4.26	0.42	0.00	
F22	8/7/02	1.62	0.16	5.65	2.53	2.66	3.55	0.57	-0.07	new day
F23	8/7/02	1.32	0.13	4.66	2.52	2.65	3.45	-0.99	-0.01	
F24	8/7/02	1.21	0.12	4.27	2.51	2.64	3.36	-0.39	-0.01	irrigation

1 cubic meter/second
= 35.314666 cubic foot/second

Prepared by Kim Howard, AGFO BioTech

Flow Data Collection Points



Niobrara River
Flow locations
Roads
Boundary Line
Section Lines

Flow collected by Kim Howard, Lil Morava and Nick Schonek, July25 - August 7, 2002

Map created by Kim Howard, 8/8/02

Appendix 6

Description of "Geologic Formations" and "Rivers and Streams" from the monument's website; "www.nps.gov/agfo".

Geologic Formations

Agate Fossil Beds National Monument is a small park in the northwest corner of Nebraska, with only 2,700 acres of federally managed land included in the 3050 acres within the park boundary. The park takes its name from thin lenses of agate (White River Silicate Group) in the area, which range in color from amber to light gray. Miocene-age rocks are exposed in the park in the bluffs above the Niobrara River wetlands and contain an excellent fossil record.

The Rocky Mountains were uplifted in many pulses of deformation between 70 to 40 million years ago. Sediments from the uplifting mountains were initially deposited near the mountains and then later transported by rivers eastward onto what eventually became the Great Plains. This river-borne silt was accompanied by wind-borne volcanic ash from eastern Nevada and western Utah, and the fine grained ash rich sediments were deposited in vast sheets called the White River beds. The earliest documented bedrock at Agate dates to the Oligocene era, 34 million years ago, but most of Agate's Oligocene deposits are well buried beneath later Miocene deposits. Oligocene-era beds are well exposed at Badlands National Park, 130 miles northeast of Agate.

During the early Miocene era, beginning about 25 million years ago, streams in the area that now includes Agate Fossil Beds National Monument shifted and cut down to produce valleys. These valleys were later filled in with sediments as the Great Plains continued to build up or aggrade. Aggradation resulted in the formation of wide savannas during the Miocene, those savannas being dotted with small water holes and the whole landscape populated with herds of animals (e.g., chalicotheres, rhinoceroses, entelodonts, beardogs, land beavers, camels, horses, pocket gophers). Ongoing research is documenting the grass species present on the ancient savanna. A major drought occurred in the Agate area during the Early Miocene. It is believed that when many of the drought-stricken and exhausted animals came to the remaining water holes in an effort to survive, the animals collapsed and died in and around the water. As the muddy water dried, the fossil beds were formed. Agate's older fossil layer is about 21 million years old and covered by a layer of ash, and its younger bed is 20 million years old. These layers are in what are now called the Harrison and Marsland Formations.

In the last five million years the High Plains have continued to uplift to their current elevation of about 4,400 feet a.m.s.l. and the savannas have changed to the grasslands of today. During the uplifting process rivers and streams have meandered across the plains and eroded the older deposits, forming the bluffs and valleys that we see today.

The modern Niobrara valley at Agate is a complex array of Late Pleistocene and Holocene geomorphology, stratigraphy, and paleosols reflecting significant climate variations over the past 12,000-15,000 years. Current research in the park is providing radiocarbon dates for the middle to late Holocene materials, documenting thousand-year-or less fluctuations between warm and cooler climates and varying amounts of annual moisture.

The agates that give the park its name are found in a thin band along ash deposits just above the Miocene bone beds, and range in color from amber to light gray. This stone is a variety of quartz (silicon dioxide) called chalcedony. Iron, manganese, and/or aluminum inclusions in the original silica deposits give the agate different colors in various locations, and often form dendritic "moss" patterns in the material.

Text and photo by Kimberly Howard, Biological Technician, Agate Fossil Beds National Monument, August 7, 2002. For further information go to www.nps.gov/agfo.

Rivers and Streams

Among the natural communities of plants and animals existing in the high plains ecosystem, none is as lush or rich in animal life as the riparian community. Riparian zones are the lush belts of vegetation found along rivers and wetlands. The Niobrara flows through the four mile length of Agate, meandering and curving to create 11 miles of river bank. These river banks play a vital role in the plant and animal communities as well as the water quality of the river.

The reach of the Niobrara river within the park is unconfined, meaning it meanders or bends throughout a wide flood plain and changes course relatively often. The flood plain of the Niobrara is a quarter-mile wide in places. This creates an interesting landscape of river twists and turns and oxbow ponds and sloughs filled with cattails, irises, reeds and water loving plants and a great environment for a diverse variety of wildlife. Oxbow ponds are the horseshoe shaped ponds that are the result of a very sharp bend being cut off from the river. Along the river banks, reeds and cattails grow tall and hang over the river providing shade to keep the water cool and reduce the amount of evaporation during hot days.

Though the Niobrara River is the only continuously flowing water in the park there are several ephemeral tributaries to the river. Tributaries are streams that run into and contribute water to a river or larger stream. Ephemeral streams are streams that only flow after a major rain event and can be identified by dry channels in depressions between hills. These are the types of areas in which flash floods can occur that cause death and destruction of property. Though the streams rarely flow and do not flow for very long, they are erosive, sometimes carrying large amounts of sediment to the river. Sediment, soil and sand material that is suspended in the flow of the water deposits when flow slows down, when there is less water or when the water is spread over a greater area.

A major source of water for the Niobrara in and around the park is ground water, water that is stored in and released from aquifers and reservoirs. These large, underground reservoirs can be refilled by rainfall if water can infiltrate that far into the ground.

Groundwater naturally comes to the surface through seeps and springs but is also brought up by wells. A spring is place where groundwater flows naturally from the soil or rock formation onto the land surface or into a body of surface water. Seeps are similar but are usually less defined and do not flow as springs do; here they are characterized by creating a marshy area near the river. There is little specific information known about Agate's groundwater but park staff are currently involved in projects to learn more to be able to better manage groundwater use.

The river running through the park creates a special prairie habitat that is not seen in drier areas. The meandering river creates about 200 acres of riparian area which is the greener, wetter areas near a stream where specialized plants grow. Plants such as willows, reeds, sedges and wild licorice thrive in the riparian areas. Willows and other water-loving shrubs and trees provide browse for white-tail deer. The riparian area also provides home for salamanders and frogs that need more moisture than the dry uplands provide. Park staff carefully monitor and manage the riparian area to restore it to its natural condition by controlling non-native plant species such as the Canada thistle. To learn more about these efforts, look at the Canada thistle page.

Quality of water is enhanced by the riparian areas as the two are interdependent. Trees and shrubs shade the water, reducing evaporations and keeping water cooler which is beneficial to aquatic life. Overall, the water quality at Agate is good, having low levels of nitrates and phosphates that are monitored through yearly sampling. Agate also monitors water quality using by observing macroinvertebrates (insects and other arthropods) that live in the water. Macroinvertebrates are sensitive to pollution and extreme flow fluctuation, so a decrease in species diversity can indicate a problem with the water quality. The Niobrara river is not extremely large at Agate, generally only about 2.5 meters (8.25 feet) wide and flows at around eleven cubic feet per second.

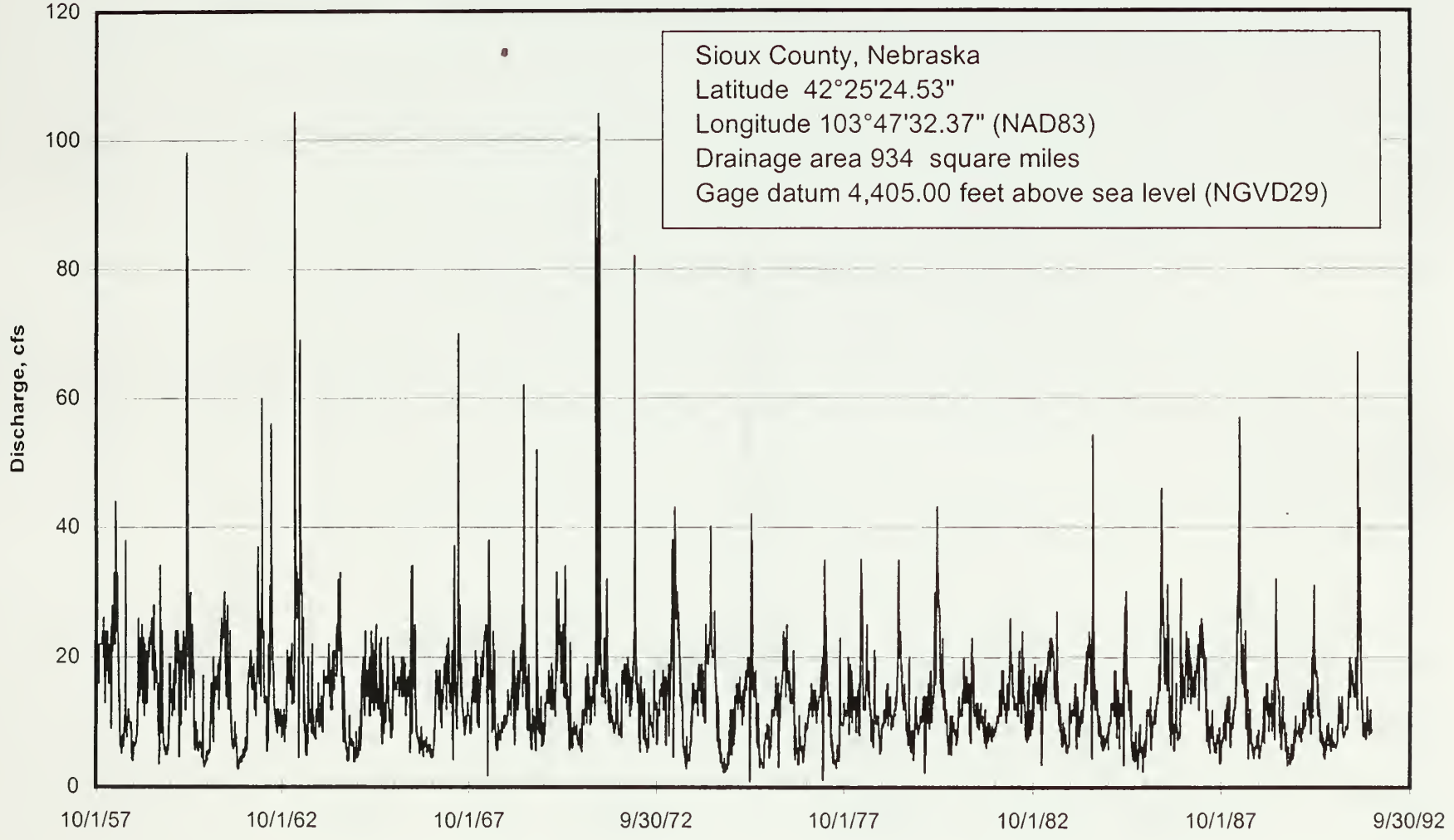
Text and photo by Kimberly Howard, Biological Technician, Agate Fossil Beds National Monument, August 6, 2002. For more information go to www.nps.gov/agfo.

Appendix 7

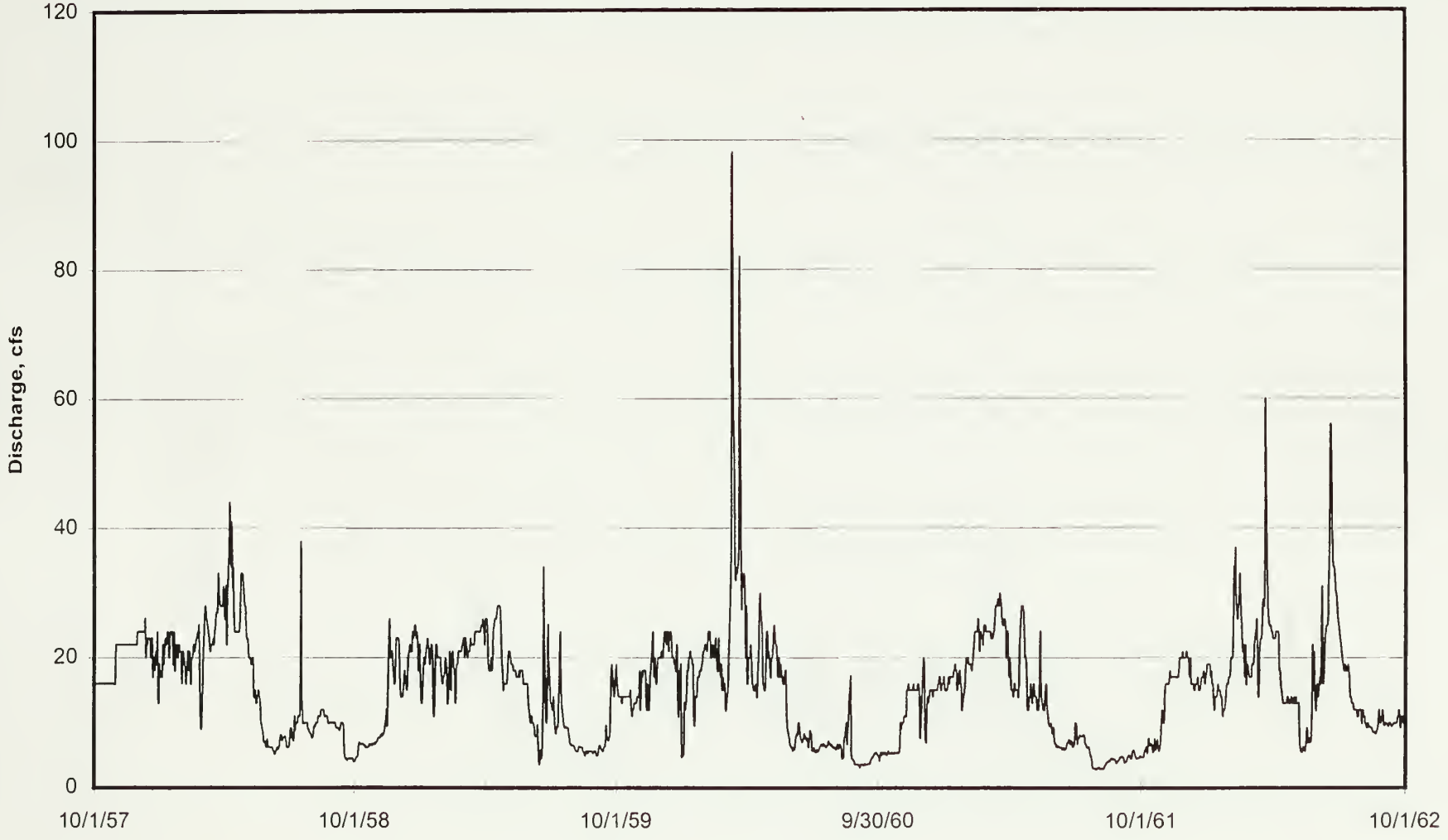
Hydrographs of streamflow in the Niobrara River at Agate, Nebraska; USGS data from 1957-91

Hydrographs from the period that the USGS operated the streamflow gaging station. Data are available from the USGS websited “http://nwis.waterdata.usgs.gov/nwis/”

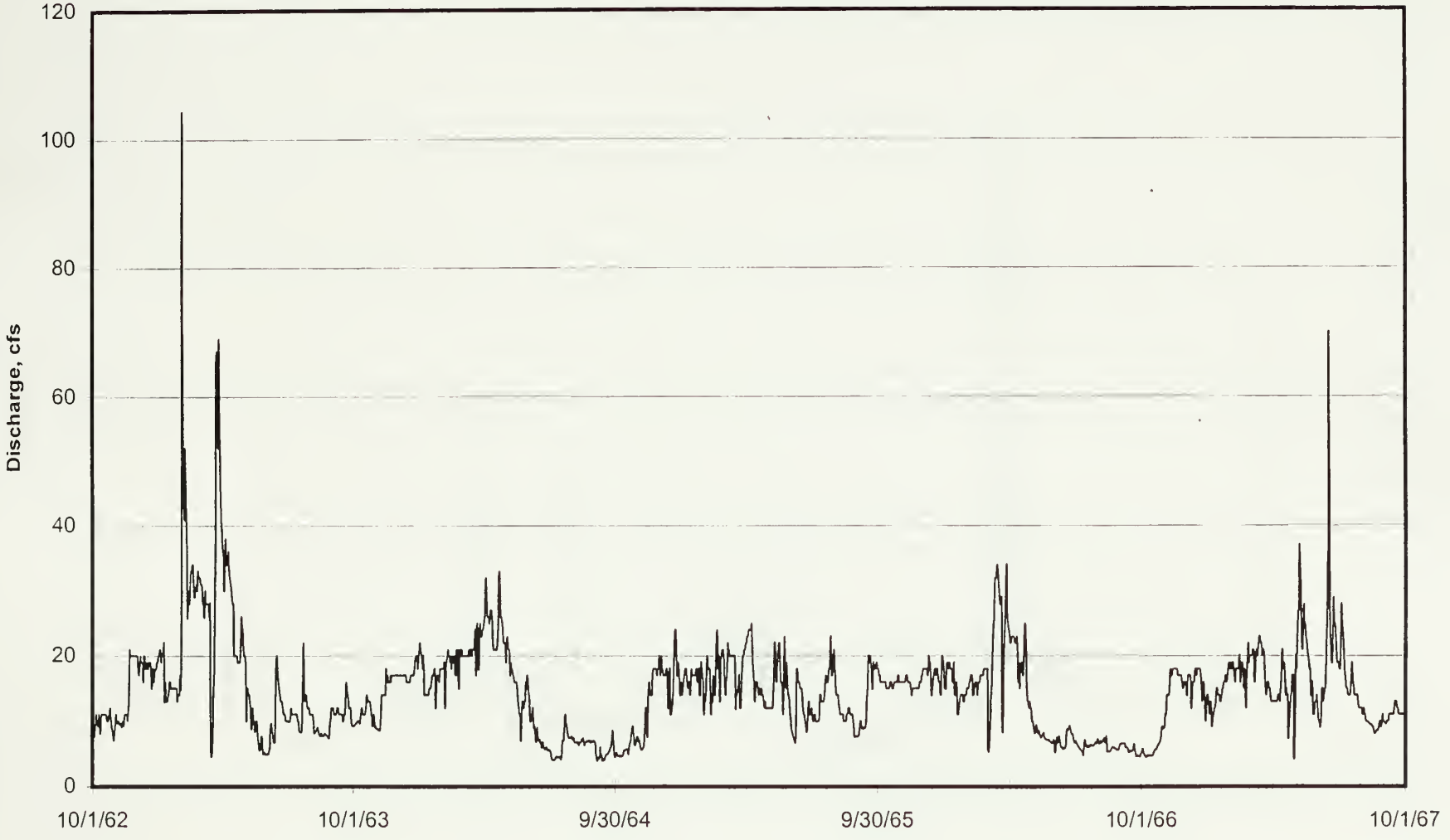
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



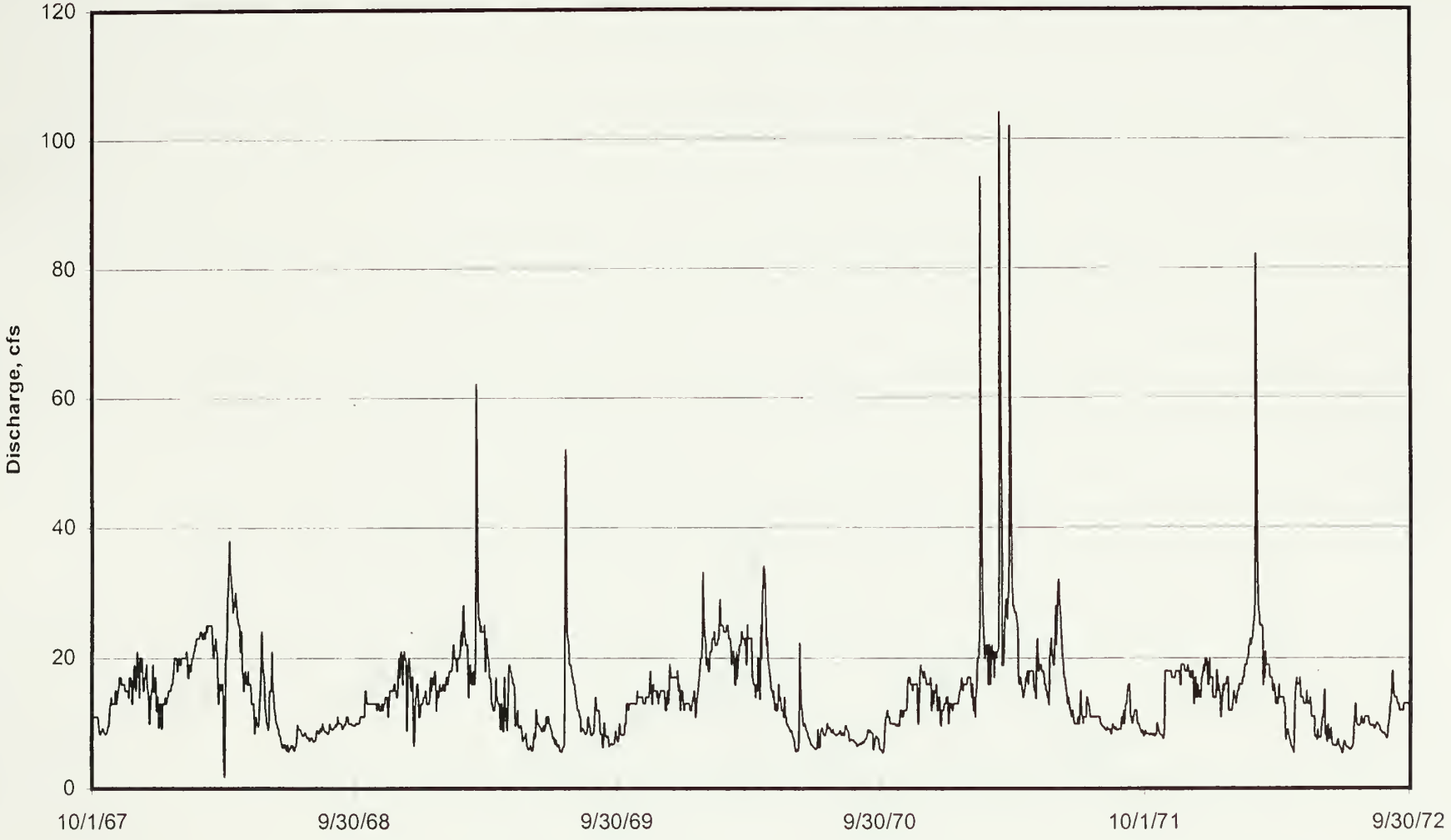
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



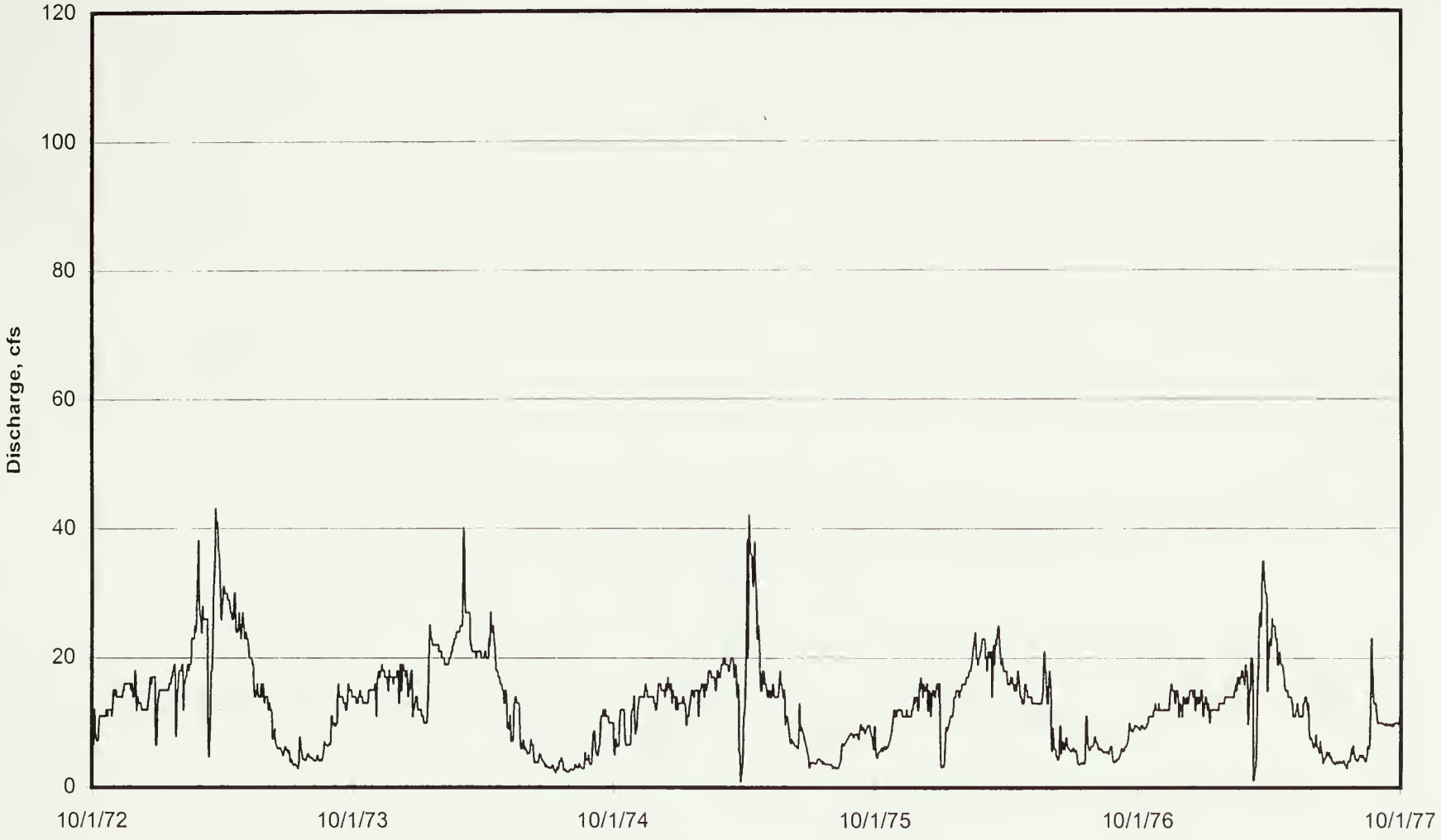
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



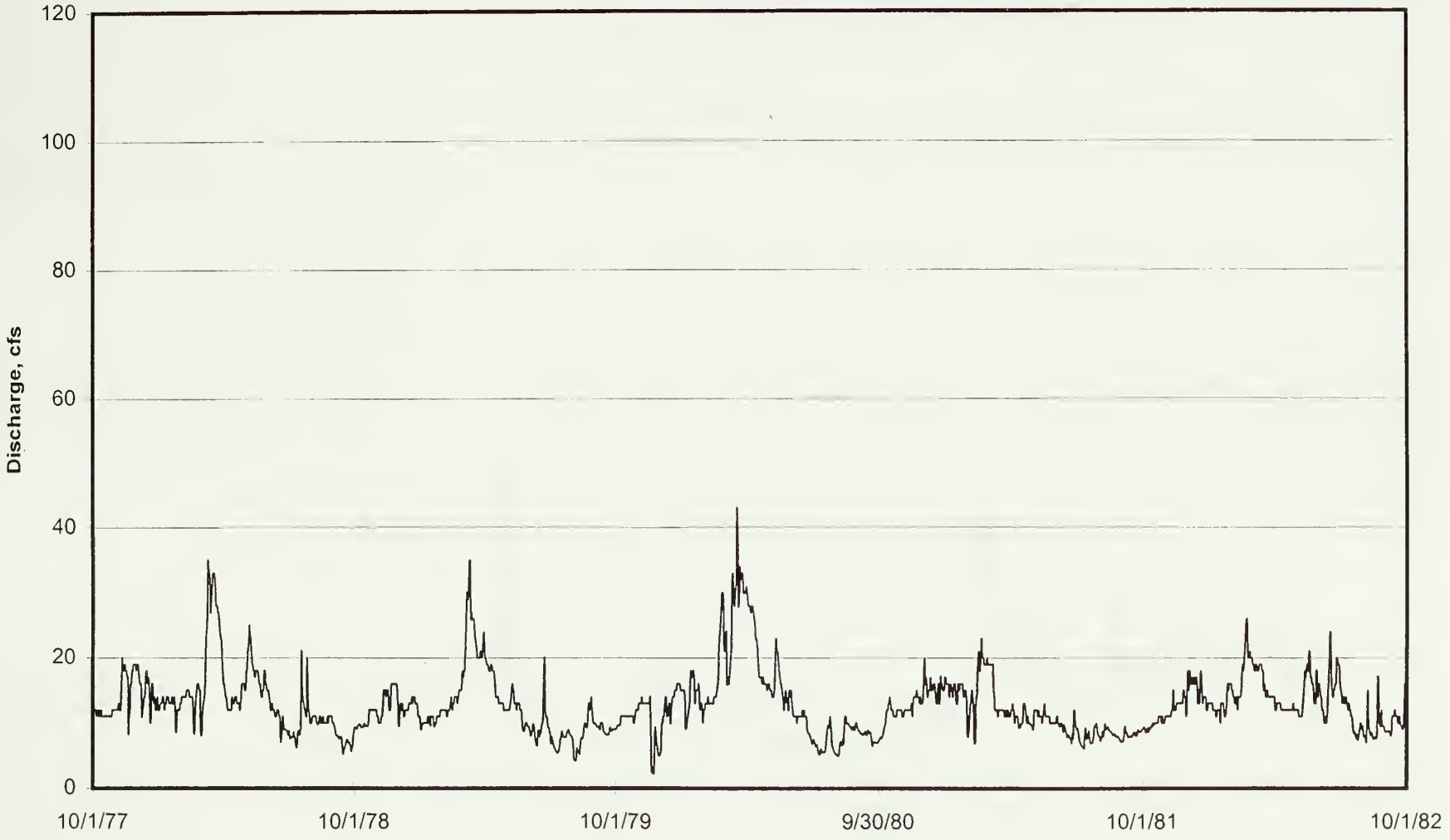
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska

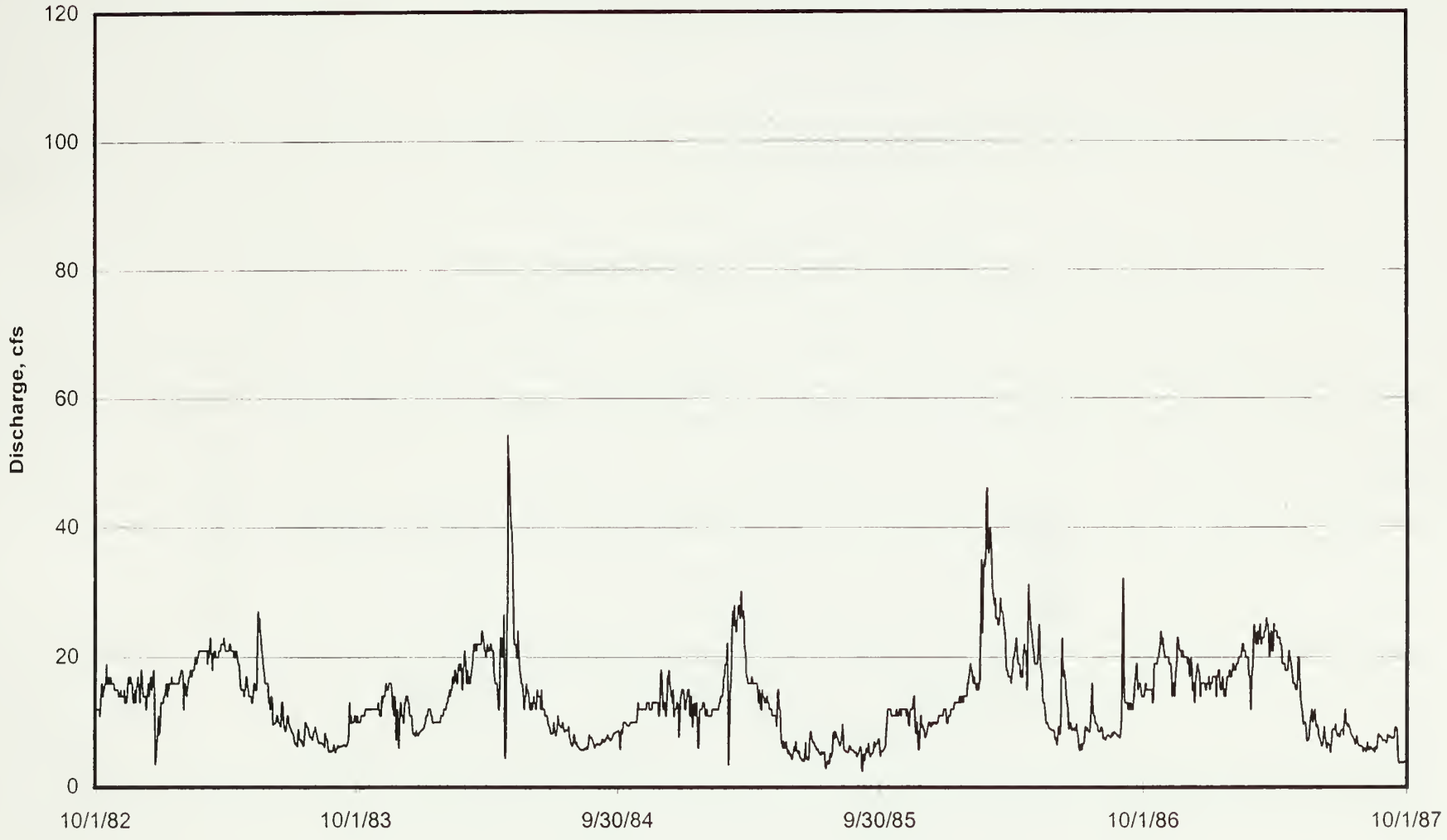


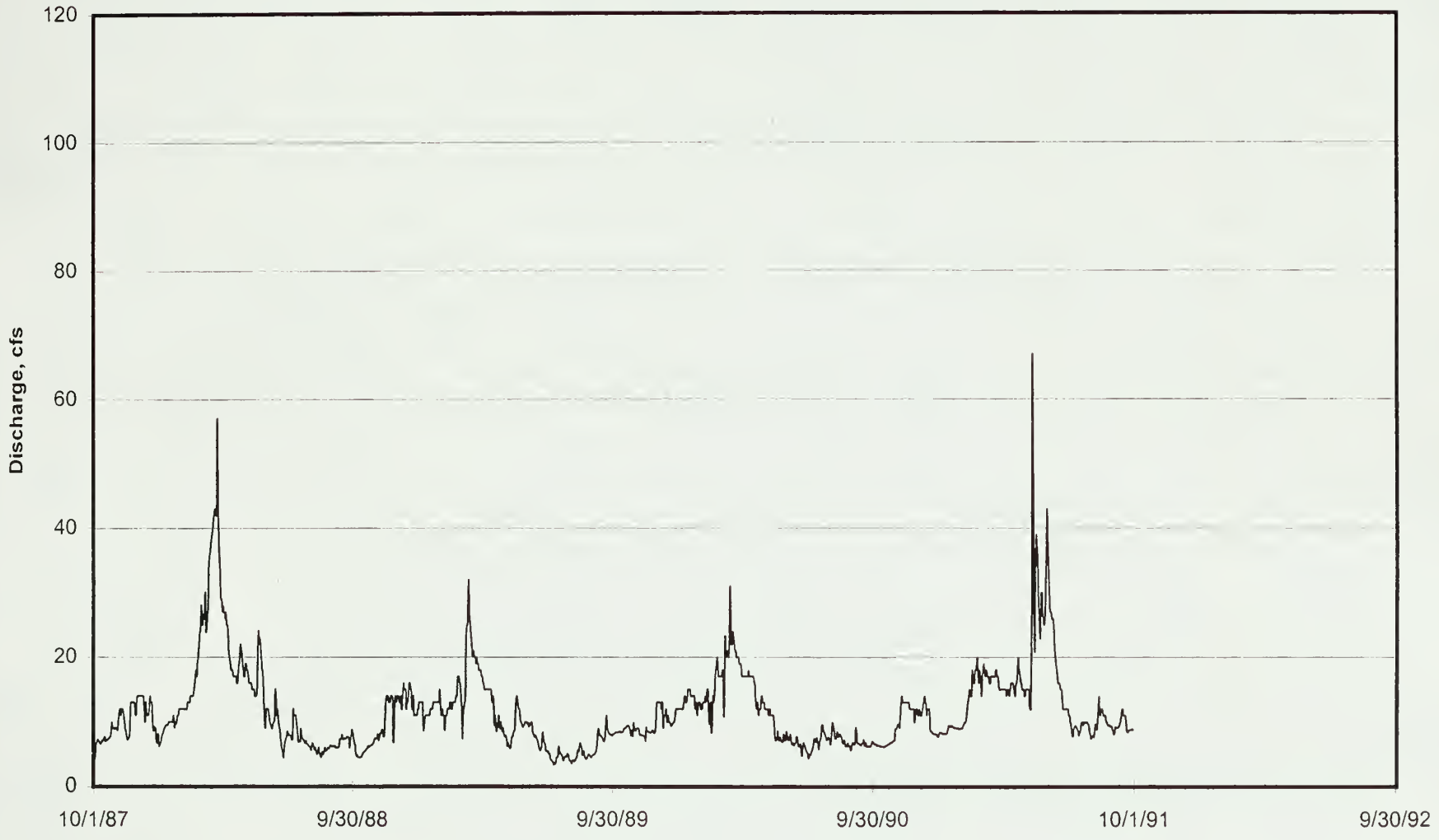
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska




USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska
Discharge, cfs
120
100
80
60
40
20
0
10/1/82
10/1/83
9/30/84
9/30/85
10/1/86
10/1/87


USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska
Discharge, cfs
120
100
80
60
40
20
0
10/1/87
9/30/88
9/30/89
9/30/90
10/1/91
9/30/92

Appendix 8

Streamflow records for the Niobrara River at Agate, Nebraska, 1995-2004

Data and hydrographs of streamflow in the Niobrara River during the period the gaging station was operated by NPS personnel.

Streamflow Records for the Niobrara River at Agate, Nebraska. 1995-2004 Station 06454100

August 2004

Prepared by:
Larry Martin
National Park Service
Water Resources Division
1201 Oakridge Drive, Suite 250
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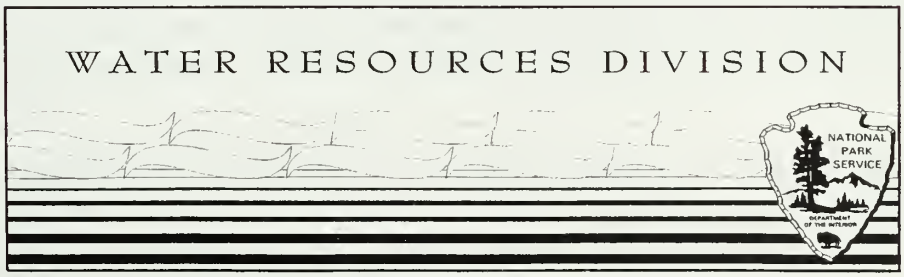
(970)-225-3515



National Park Service - Department of the Interior
Fort Collins - Denver - Washington

The USGS operated a streamflow gaging station on the Niobrara River just upstream of the Highway 29 bridge from 1957-91 (Station Number 06454100). Data for the period when USGS operated the gaging station are available from http://nwis.waterdata.usgs.gov/ne/nwis/discharge. Select the box for "site number" and enter "06454100". This will provide access to the historical data collected by USGS from 1957-91.

National Park Service staff at Agate Fossil Beds National Monument have operated the chart recorder at the site since 1995. The record since 1995 is not continuous because there were many times when the recorder was not functioning properly.

The charts from the recorder for the period from 1995-2004 were analyzed and average daily streamflow values were computed for periods when the chart recorder was operating. Charts were analyzed to determine the average stage of the stream for a particular day. The values for date and stage were entered in an Excel spreadsheet. The stage data were converted to average daily streamflow by applying a regression equation that was developed from the rating curve for the site. The rating curve and regression equation are included in this report. The data were then put in tabular format by water year, similar to the standard USGS format for publishing hydrographic data. These tables and a hydrograph for each year are included in this report.

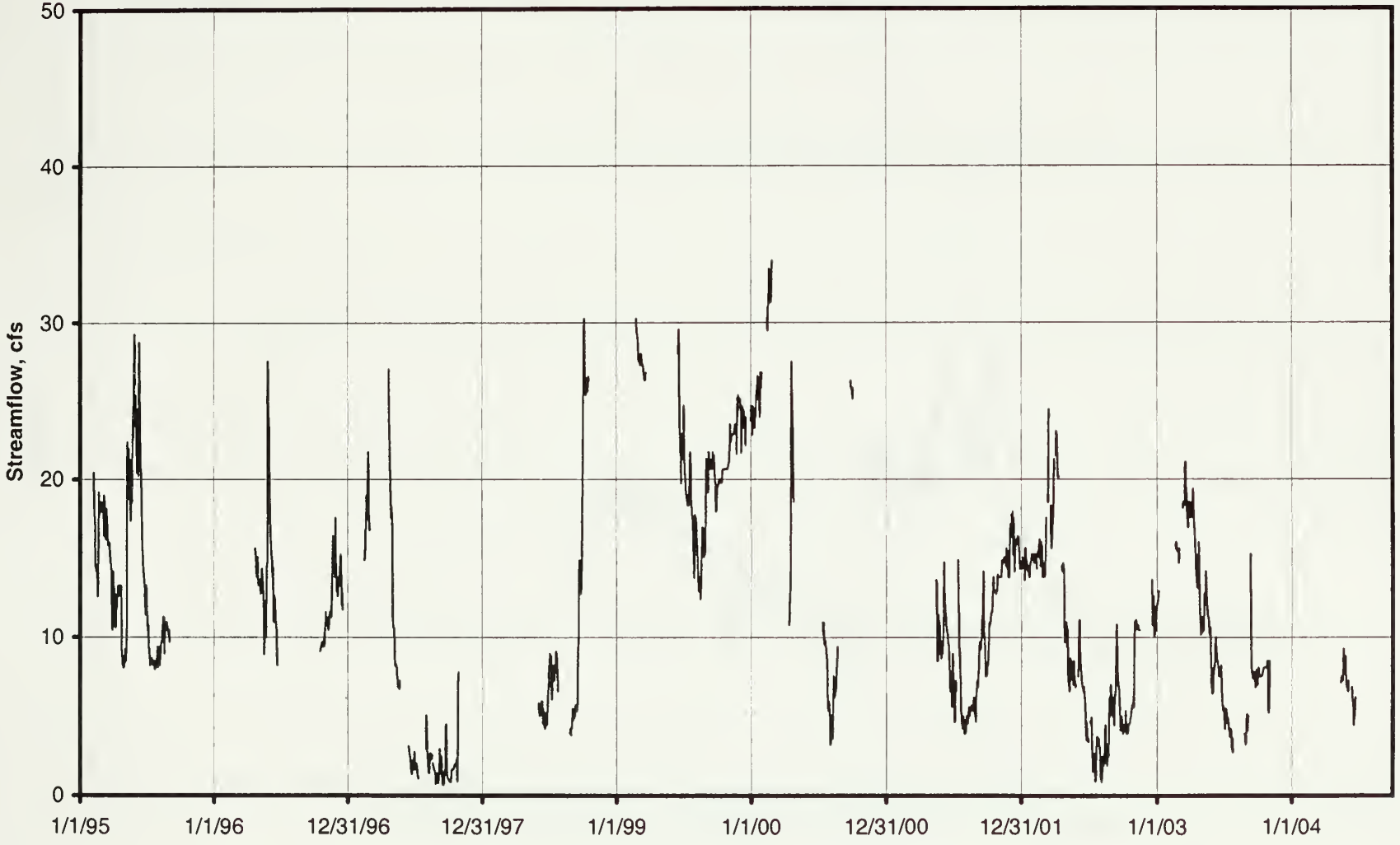
In FY-03, the USGS was contracted to conduct streamflow gaging at this site to evaluate the stage-discharge rating curve for the site. USGS also conducted repair and maintenance of the chart recorder and associated equipment to make certain that it was in good operating condition. Data collected in 2002-03 are shown on a figure in this report along with the rating curve that was used prior to 1991. The data from 2003-03 show that the rating curve is still a fairly reliable tool for converting stage (water level) in the stream to flow rates.

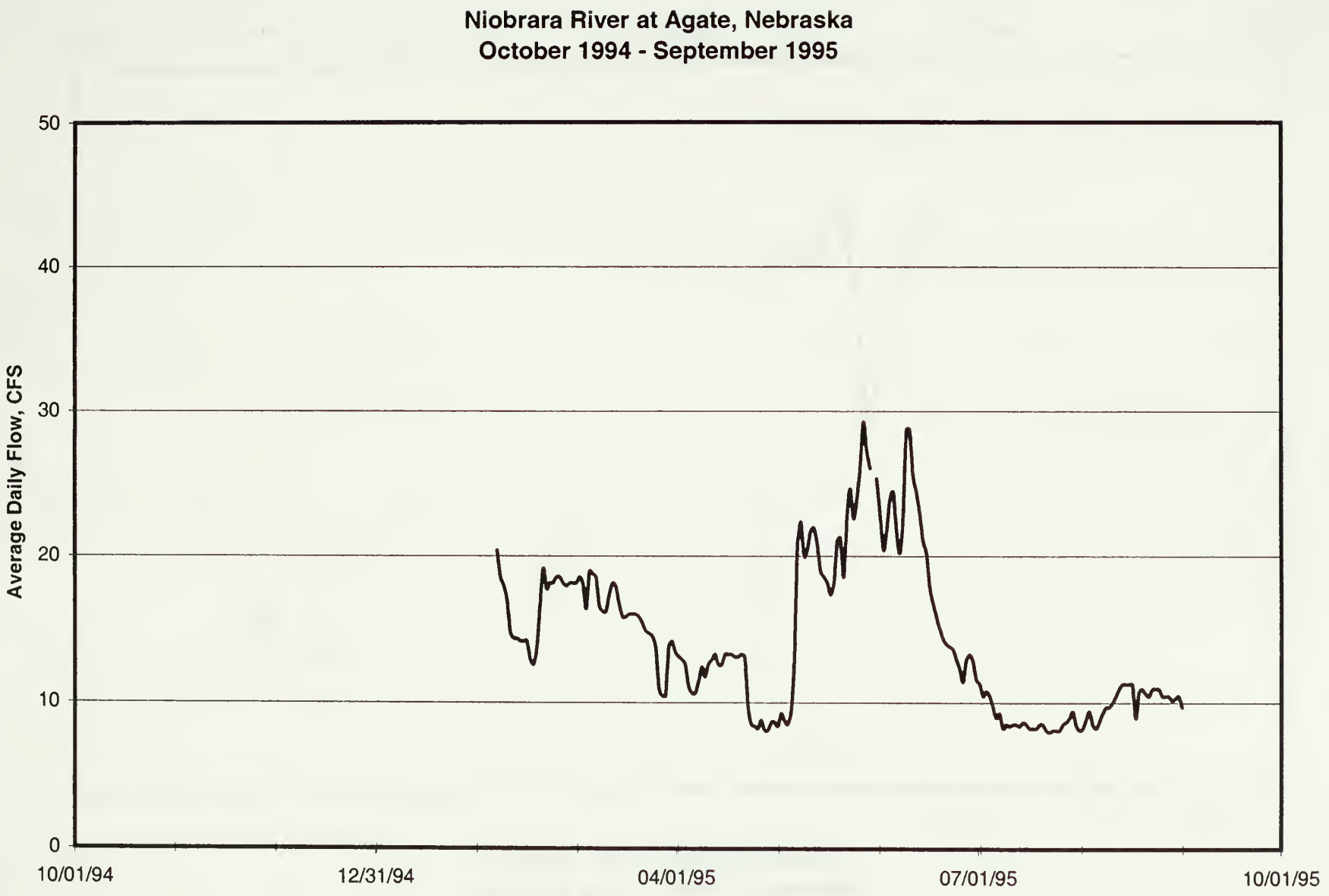
Nebraska DNR is interested in operating a gaging station at this site to assist in their administration of water rights on the Niobrara River. DNR is willing to operate the gaging station and publish the data in their annual "Hydrographer's Report" if NPS would provide funding for the initial purchase of digital recording equipment for the site. The digital recording equipment has been purchased and is in storage at the park. It will be installed after agreements for operation of the gaging station have been negotiated between the NPS, Nebraska DNR, and the landowner.

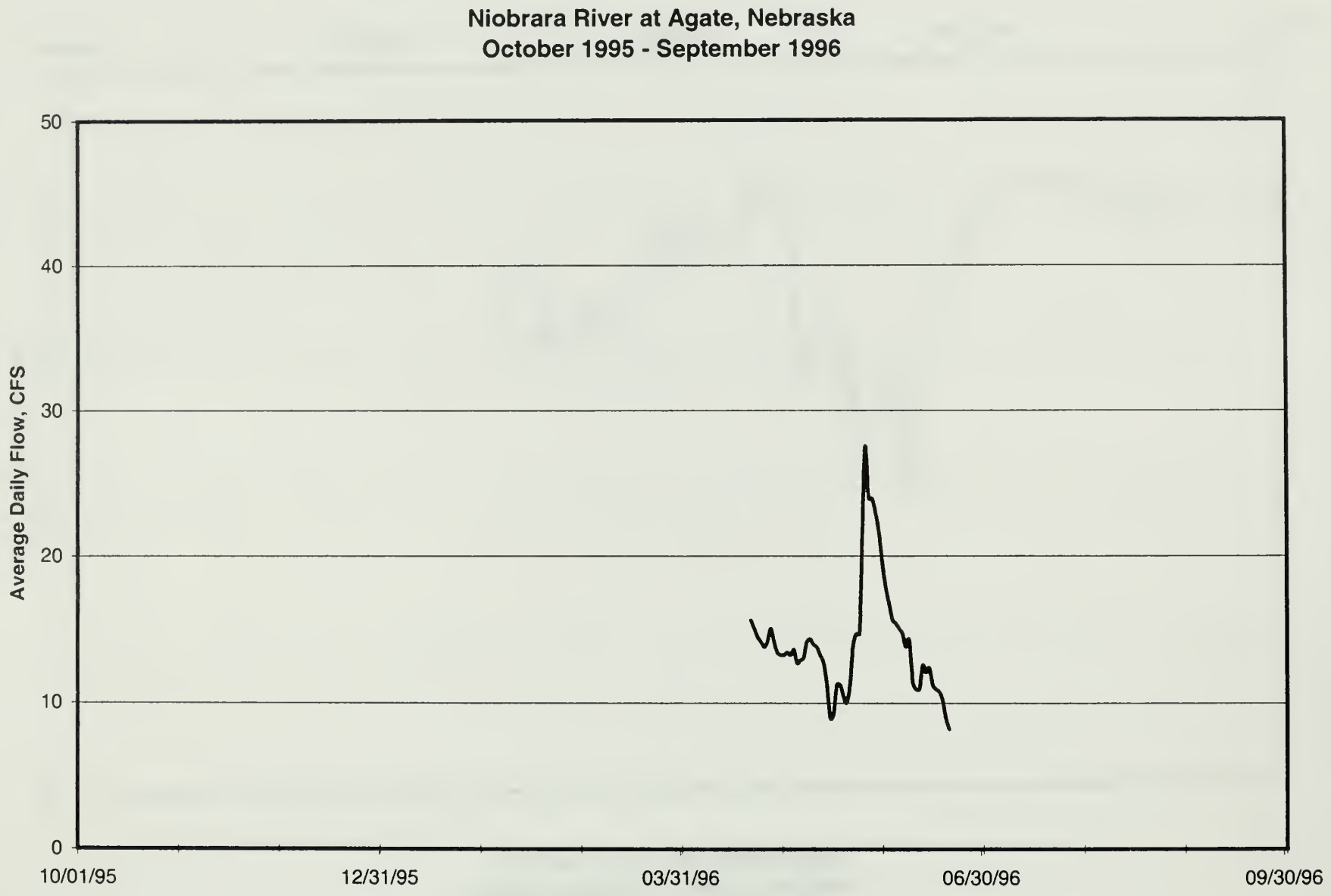
The data analysis and preparation of this report was by Larry Martin, NPS-Water Resources Division, Ft. Collins, CO. Lil Morava at Agate Fossil Beds operated the chart recorder and collected the field data. Dan Hitch, USGS, made the streamflow measurements in 2002-03.

Hydrographs

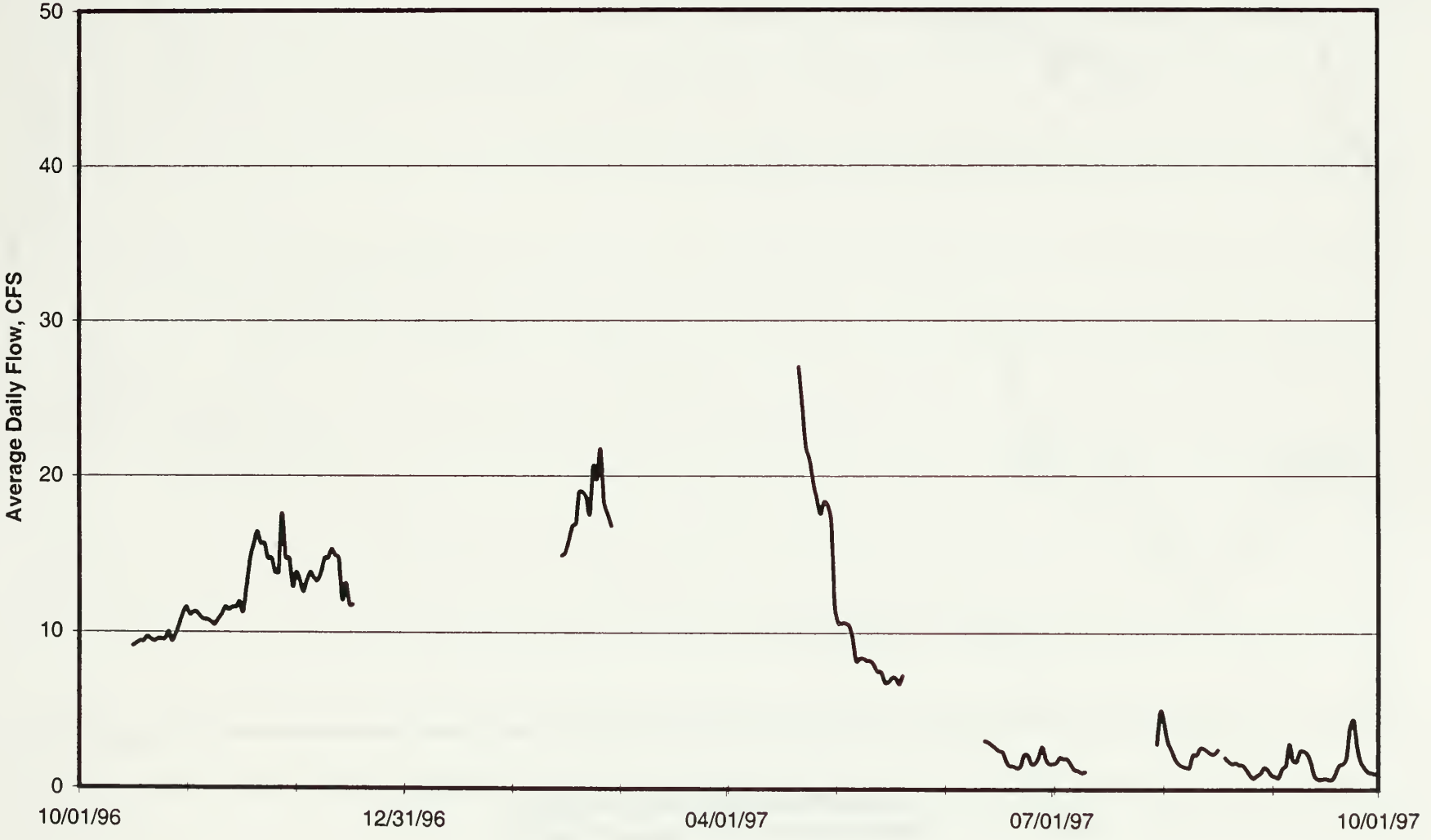
Niobrara River at Agate, Nebraska
February 1995 to June 2004



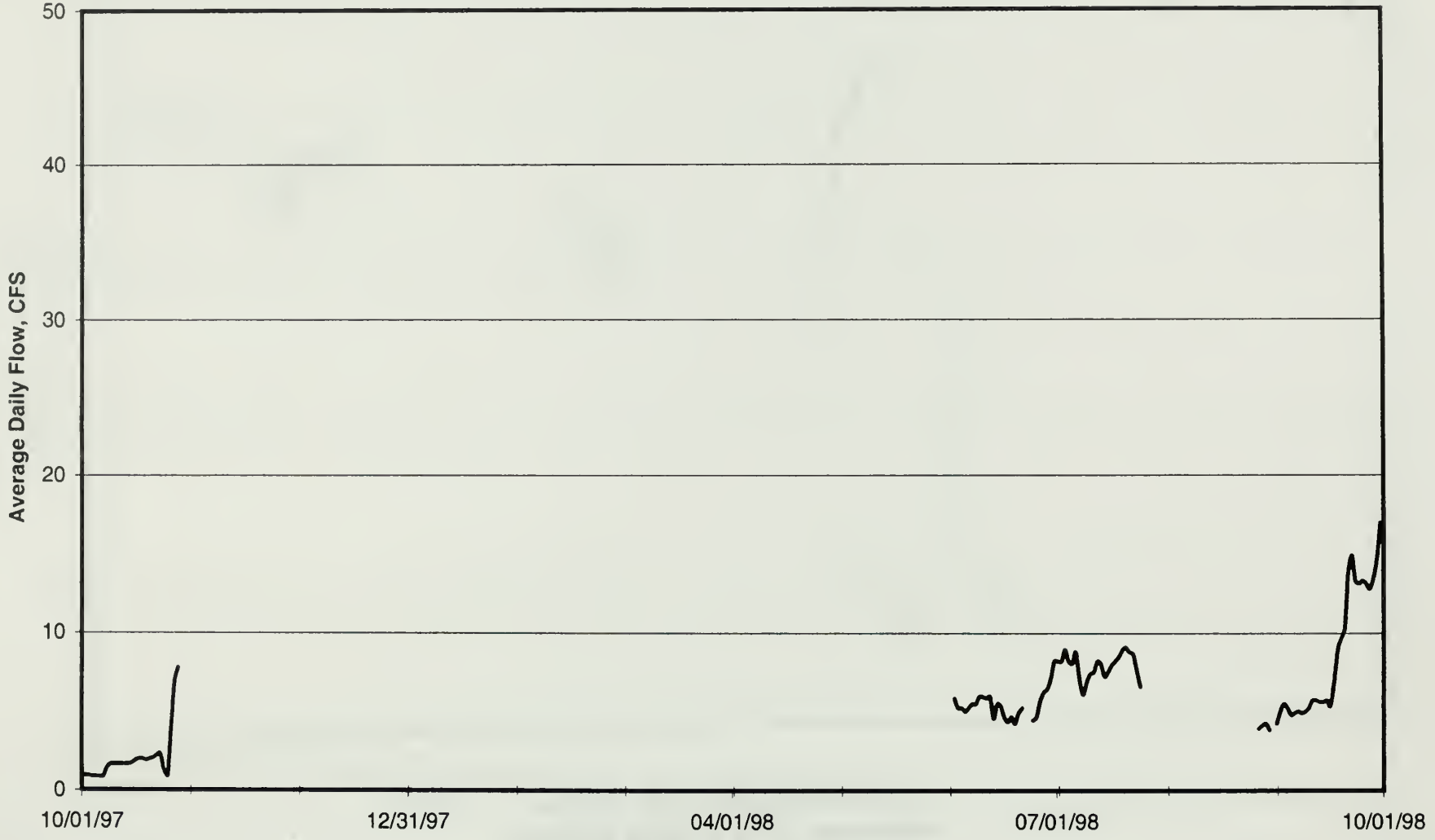

Niobrara River at Agate, Nebraska
October 1994 - September 1995
Average Daily Flow, CFS
50
40
30
20
10
0
10/01/94
12/31/94
04/01/95
07/01/95
10/01/95


Niobrara River at Agate, Nebraska
October 1995 - September 1996
Average Daily Flow, CFS
50
40
30
20
10
0
10/01/95
12/31/95
03/31/96
06/30/96
09/30/96

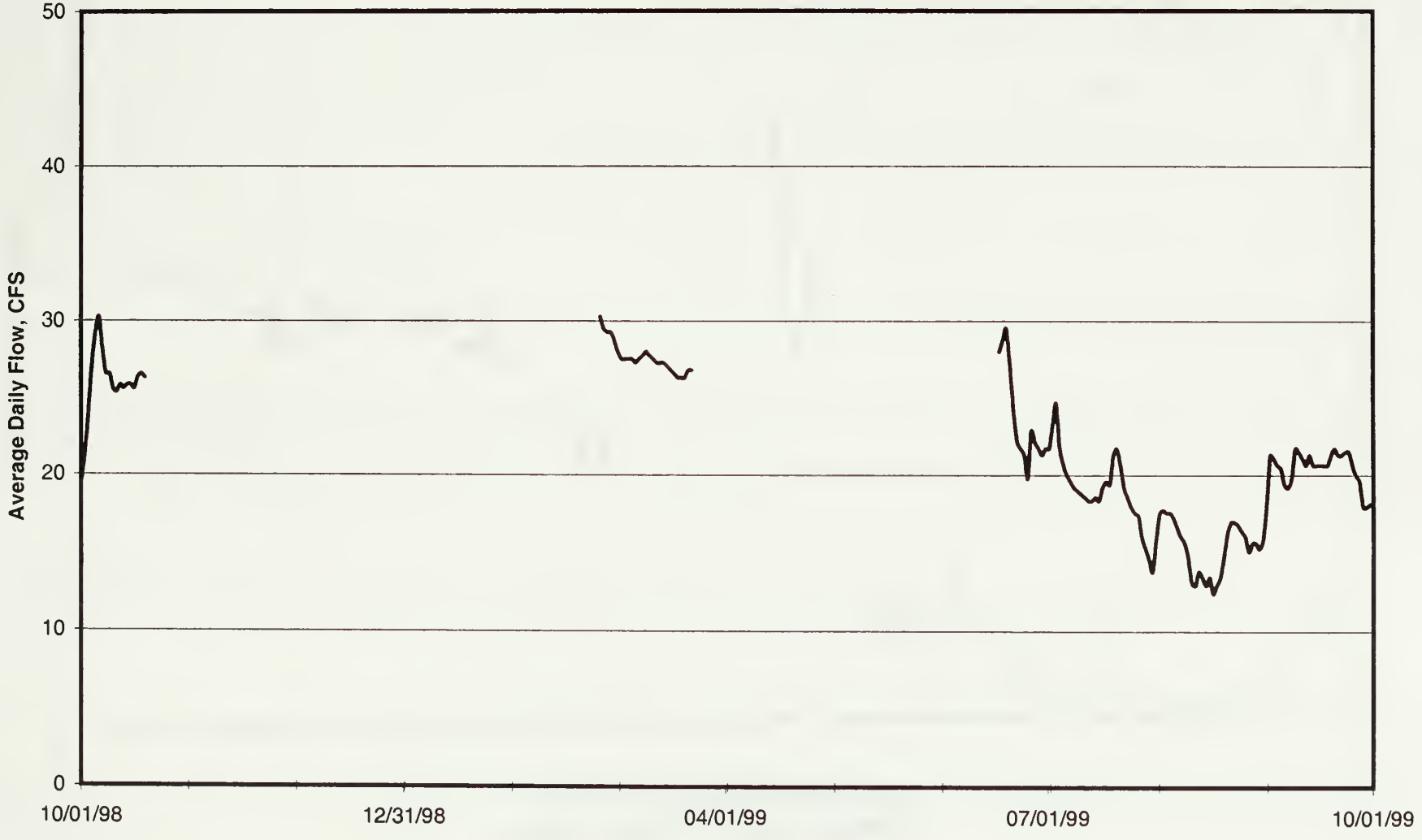
Niobrara River at Agate, Nebraska
October 1996 - September 1997



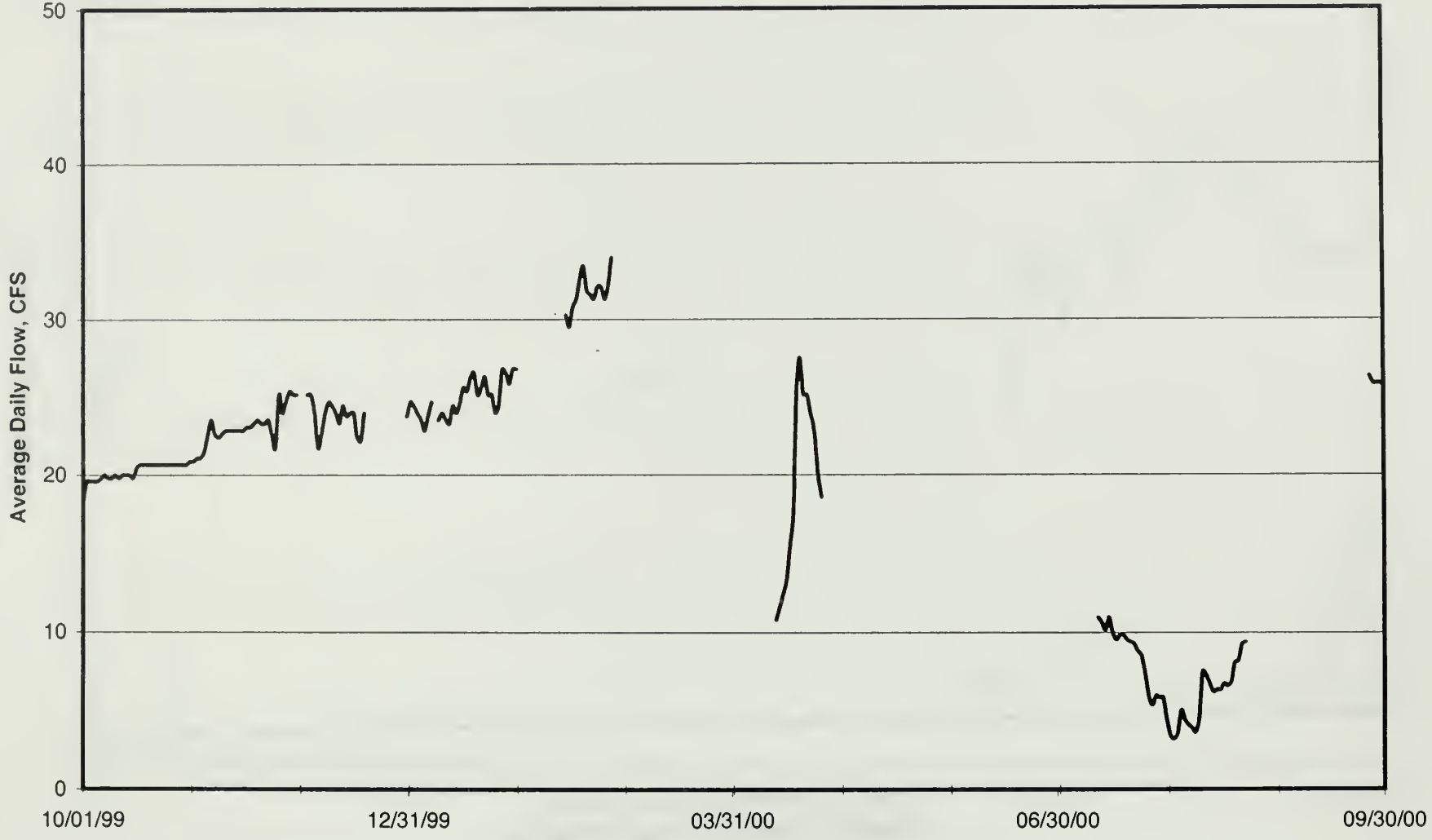
Niobrara River at Agate, Nebraska
October 1997 - September 1998



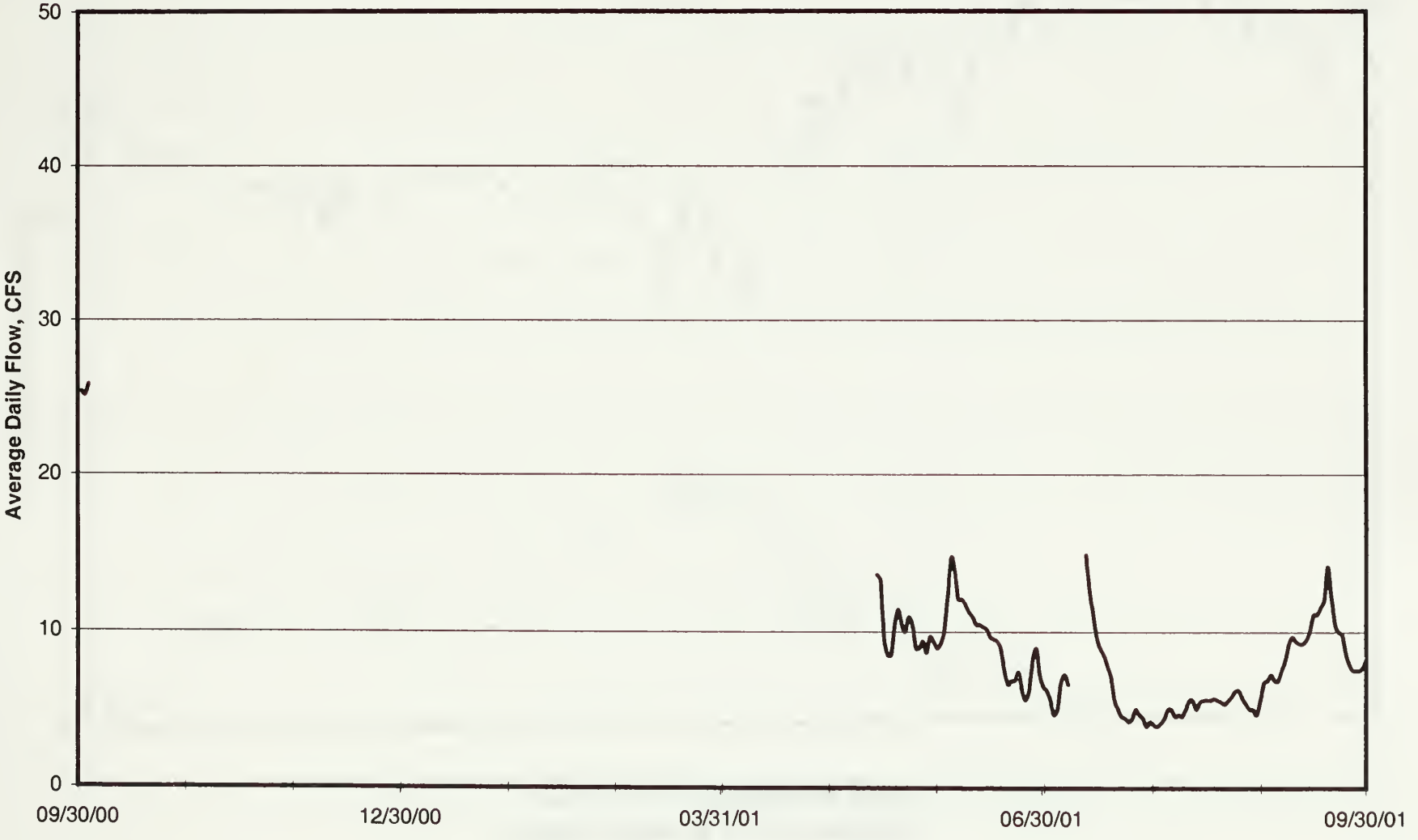
Niobrara River at Agate, Nebraska
October 1998 - September 1999



Niobrara River at Agate, Nebraska
October 1999 - September 2000



Niobrara River at Agate, Nebraska
October 2000 - September 2001



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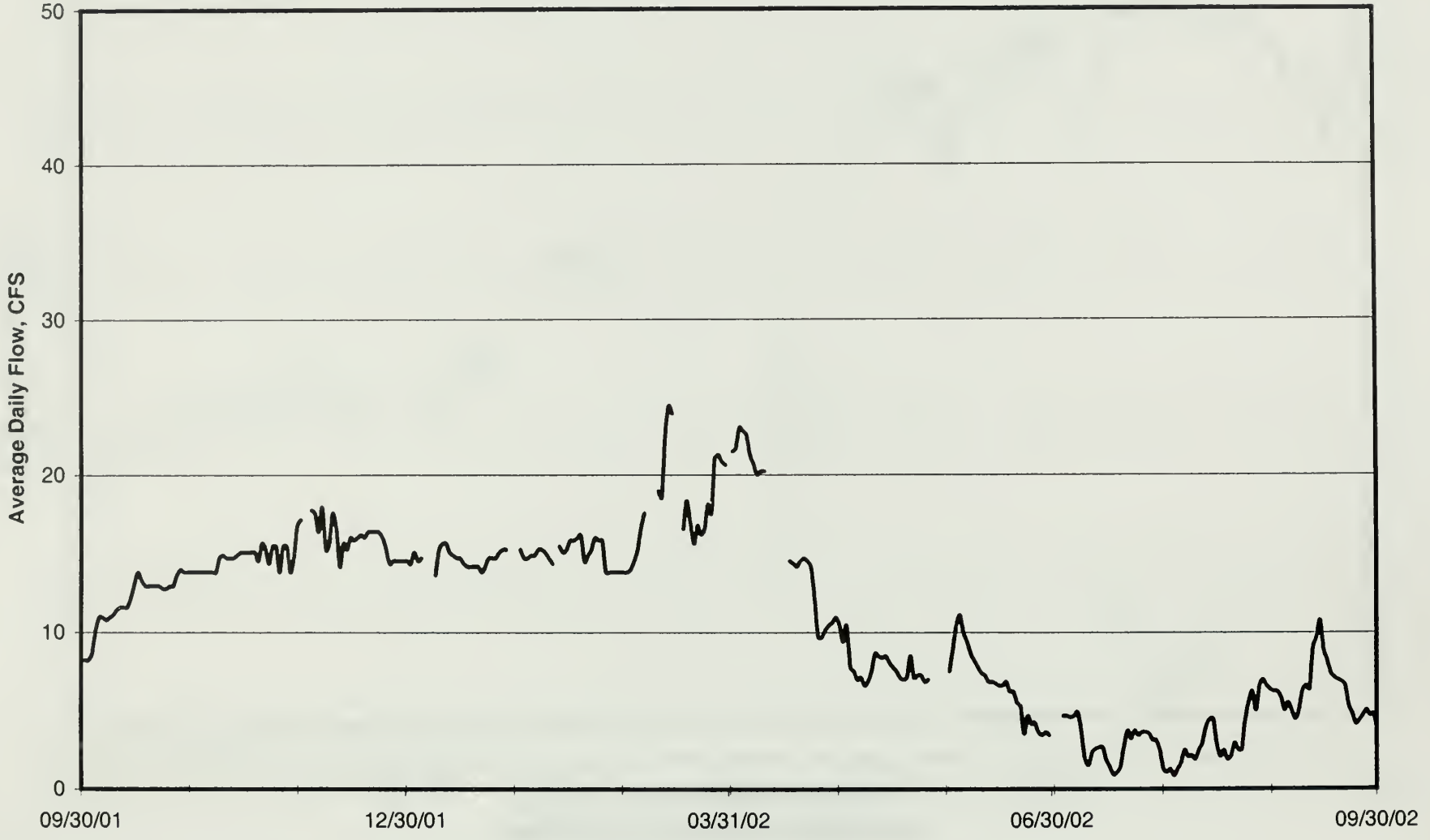
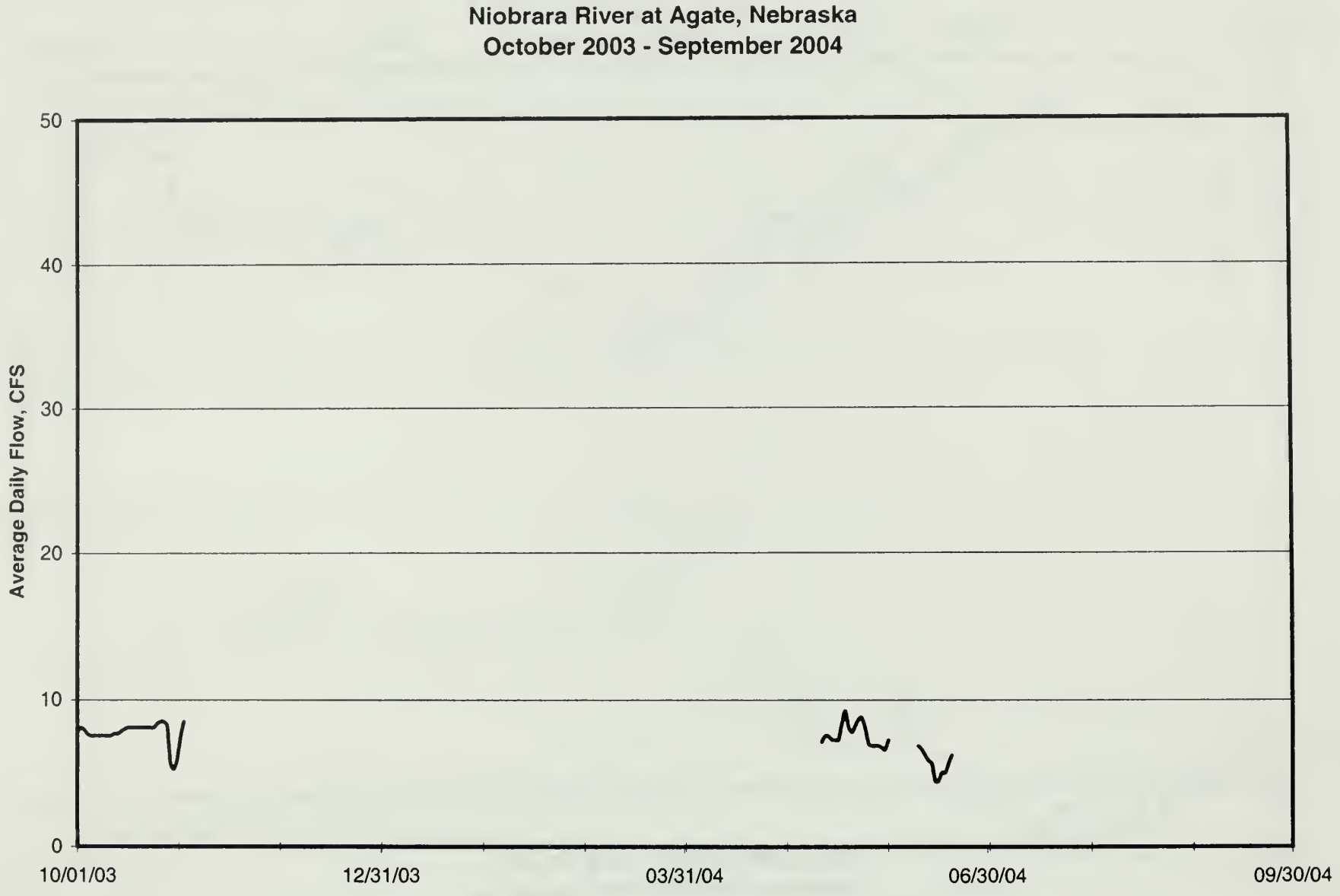
October 2001 - September 2002



Niobrara River at Agate, Nebraska
October 2002 - September 2003


Niobrara River at Agate, Nebraska
October 2003 - September 2004
Average Daily Flow, CFS
50
40
30
20
10
0
10/01/03
12/31/03
03/31/04
06/30/04
09/30/04

Data Tables

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 1994 through September 1995

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1						18.2	13.4	8.7	25.4	11.6	8.1	9.7
2						18.2	13.1	8.4	22.8	11.3	8.2	
3						18.6	12.9	9.3	20.4	10.5	8.8	
4						18.2	12.6	8.8	21.7	10.8	9.4	
5						16.4	11.1	8.5	24.0	10.5	8.5	
6					20.4	19.0	10.6	9.4	24.4	9.7	8.2	
7					18.6	18.8	10.6	12.8	21.7	9.0	8.7	
8					18.0	18.6	11.4	20.6	20.2	9.3	9.3	
9					17.0	16.6	12.4	22.4	22.8	8.2	9.7	
10					14.7	16.2	11.8	20.0	28.8	8.5	9.7	
11					14.3	16.2	12.6	20.4	28.8	8.4	10.0	
12					14.3	17.4	12.9	21.7	25.6	8.5	10.5	
13					14.2	18.2	13.3	21.9	24.4	8.5	10.9	
14					14.2	18.0	12.6	20.9	23.1	8.4	11.3	
15					14.2	16.8	12.6	19.0	21.1	8.7	11.3	
16					12.9	15.8	13.3	18.6	20.2	8.5	11.3	
17					12.6	15.8	13.3	18.2	18.0	8.2	11.3	
18					13.8	16.0	13.3	17.4	16.8	8.2	9.0	
19					16.6	16.0	13.1	18.2	15.8	8.2	10.8	
20					19.2	16.0	13.1	21.1	15.1	8.5	10.9	
21					17.8	15.8	13.3	21.3	14.3	8.5	10.6	
22					18.2	15.4	13.1	18.6	14.0	8.1	10.5	
23					18.2	14.9	9.7	22.8	13.8	8.0	10.9	
24					18.6	14.7	8.5	24.7	13.6	8.1	10.9	
25					18.6	14.5	8.4	22.6	12.9	8.1	10.9	
26					18.2	13.8	8.2	24.0	12.2	8.1	10.5	
27					18.0	10.9	8.8	26.3	11.4	8.5	10.5	
28					18.2	10.5	8.1	29.3	12.9	8.7	10.5	
29						10.5	8.1	27.3	13.3	9.0	10.2	
30						13.8	8.7	26.1	12.8	9.4	10.3	
31						14.2				8.5	10.5	

Niobrara River at Agate. Nebraska, Station 06454100												
Discharge, Cubic Feet per Second, Water Year October 1997 through September 1998												
Daily Mean Values												
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.0									8.2		4.3
2	0.9									8.2		5.0
3	0.9								5.9	8.2		5.5
4	0.9								5.3	9.0		5.3
5	0.9								5.3	8.2		4.8
6	0.9								5.0	8.1		4.9
7	0.9								5.3	8.8		5.0
8	1.4								5.5	7.1		4.9
9	1.7								5.5	6.1		5.0
10	1.7								6.0	6.9		5.3
11	1.7								6.0	7.4		5.8
12	1.7								5.9	7.6		5.8
13	1.7								6.0	8.2		5.6
14	1.7								4.6	8.1		5.6
15	1.8								5.5	7.3		5.8
16	1.9								5.4	7.6		5.4
17	2.0								4.7	8.0		6.9
18	2.0								4.4	8.2		9.0
19	1.9								4.7	8.5		9.7
20	2.0								4.3	9.0		10.3
21	2.1								4.9	9.1		13.8
22	2.2								5.3	8.8		14.9
23	2.3									8.7		13.3
24	1.3									7.7		13.1
25	0.9								4.5	6.6		13.3
26	4.0								4.7			13.1
27	6.9								5.6		4.0	12.8
28	7.8								6.2		4.2	13.4
29									6.5		4.3	14.7
30									7.1		3.9	17.0
31												

Niobrara River at Agate. Nebraska, Station 06454100												
Discharge, Cubic Feet per Second, Water Year October 1998 through September 1999												
Daily Mean Values												
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	19.6					28.8				21.7	15.8	18.2
2	21.3					28.0				21.7	17.6	21.3
3	23.7					27.5				23.3	17.8	21.1
4	27.0					27.5				24.7	17.6	20.6
5	29.3					27.5				21.7	17.6	20.4
6	30.3					27.5				20.6	17.2	19.4
7	28.3					27.3				20.0	16.6	19.2
8	26.5					27.5				19.6	16.0	19.8
9	26.5					27.8				19.2	15.6	21.7
10	25.6					28.0				19.0	14.7	21.5
11	25.4					27.8				18.8	13.1	21.1
12	25.8					27.5				18.6	12.9	20.6
13	25.6					27.3				18.4	13.8	21.3
14	25.8					27.3				18.4	13.4	20.6
15	25.8					27.3				18.6	12.9	20.6
16	25.6					27.0				18.4	13.4	20.6
17	26.3					26.8				19.2	12.4	20.6
18	26.5					26.5			28.0	19.6	12.9	20.6
19	26.3					26.3			28.8	19.4	13.4	21.3
20						26.3			29.5	21.3	14.7	21.7
21						26.3			27.3	21.7	16.2	21.3
22						26.8			24.2	20.6	17.0	21.3
23						26.8			22.2	19.2	17.0	21.5
24									21.7	18.6	16.8	21.5
25					30.3				21.3	18.0	16.4	20.6
26					29.5				19.8	17.6	16.0	20.0
27					29.3				22.8	17.4	15.1	19.6
28					29.3				22.2	16.0	15.6	18.0
29									21.7	15.3	15.6	18.0
30									21.3	14.5	15.3	18.2
31										13.8	15.8	

Niobrara River at Agate. Nebraska, Station 06454100												
	Discharge, Cubic Feet per Second, Water Year October 1999 through September 2000											
	Daily Mean Values											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	18.4	20.9		24.7							3.4	
2	19.6	21.1		24.4							3.3	
3	19.6	21.1	25.1	24.0							3.5	
4	19.6	21.5	25.1	23.5							5.0	
5	19.6	22.6	24.0	22.8							4.5	
6	19.8	23.5	21.7	23.7							4.2	
7	20.0	22.6	22.6	24.7							4.0	
8	19.8	22.4	24.0								3.6	
9	19.8	22.6	24.7	23.5							4.5	
10	20.0	22.8	24.4	24.0							7.6	
11	19.8	22.8	24.0	23.5							7.3	
12	20.0	22.8	23.3	23.3						10.9	6.8	
13	20.0	22.8	24.4	24.4			10.8			10.6	6.2	
14	20.0	22.8	23.7	24.0	30.3		11.6			10.2	6.4	
15	19.8	22.8	24.0	24.7	29.5		12.4			10.9	6.4	
16	20.4	23.1	24.0	25.6	30.8		13.3			10.0	6.8	
17	20.6	23.1	22.4	25.4	31.3		15.4			9.5	6.6	
18	20.6	23.3	22.2	26.3	32.6		17.6			9.9	6.9	
19	20.6	23.5	24.0	26.5	33.4		25.1			9.9	8.1	
20	20.6	23.3		25.1	31.8		27.5			9.5	8.2	
21	20.6	23.3		25.6	31.6		25.1			9.4	9.3	
22	20.6	23.5		26.3	31.3		25.1			9.3	9.4	
23	20.6	22.6		25.1	32.1		24.0			8.8		
24	20.6	21.7		25.1	32.1		22.8			8.5		
25	20.6	25.1		24.0	31.3		20.0			7.3		
26	20.6	24.0		24.4	32.1		18.6			5.9		26.3
27	20.6	24.7		26.8	34.0					5.4		25.8
28	20.6	25.4		26.5						6.0		25.8
29	20.6	25.1		25.8						5.9		25.8
30	20.6	25.1		26.8						5.9		25.6
31	20.9		23.7	26.8						4.5		

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 2000 through September 2001

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	25.4											
2	25.1								9.0	6.5	4.1	6.8
3	25.8								9.3	6.2	4.0	6.9
4									10.0	5.6	4.2	7.3
5									12.2	4.7	4.5	6.9
6									14.7	5.0	5.0	6.9
7									14.0	6.8	5.0	7.6
8									12.1	7.3	4.6	8.2
9									12.1	6.6	4.7	9.3
10									11.8		4.6	9.7
11									11.3		5.0	9.4
12									10.9		5.6	9.3
13									10.5		5.6	9.3
14									10.5	14.9	5.0	9.5
15									10.3	12.6	5.5	10.2
16								13.6	10.2	11.1	5.6	11.1
17								13.3	9.7	9.7	5.6	11.1
18								9.7	9.5	9.0	5.6	11.6
19								8.5	9.4	8.5	5.8	12.1
20								8.5	9.0	7.8	5.6	14.2
21								10.3	7.6	7.1	5.5	12.2
22								11.4	6.6	5.6	5.4	10.5
23								10.5	6.9	5.0	5.6	10.0
24								10.0	6.9	4.6	5.9	9.9
25								10.9	7.4	4.5	6.2	8.7
26								10.5	6.2	4.3	6.2	8.0
27								9.0	5.6	4.5	5.8	7.6
28								9.0	6.2	5.0	5.4	7.6
29								9.4	8.2	4.7	5.0	7.6
30								8.7	9.0	4.5	5.0	7.8
31								9.7	7.3	4.0	4.7	8.4
								9.4		4.3	5.6	

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 2001 through September 2002

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8.2	13.8	17.20	14.3	15.3	13.8		10.9			1.3	6.2
2	8.2	13.8		15.1	14.7	13.8	21.5	10.5	7.6		1.1	6.2
3	8.7	13.8		14.5	14.7	13.8	21.7	9.4	9.0		1.3	5.9
4	10.2	13.8	17.8	14.7	14.9	14.0	23.1	10.5	10.5	4.7	0.9	5.0
5	10.9	13.8	17.6		14.9	14.5	22.8	7.8	11.1	4.7	1.3	5.5
6	10.9	13.8	16.4		15.3	15.3	22.6	7.6	10.0	4.6	1.7	5.0
7	10.8	13.8	18.0		15.3	16.6	21.3	7.0	9.4	4.7	2.5	4.5
8	10.9	14.7	15.3	13.6	15.1	17.6	20.6	7.1	8.7	4.9	2.1	5.0
9	11.1	14.9	15.6	15.3	14.7		20.0	6.6	8.2	3.6	2.2	6.2
10	11.4	14.7	17.6	15.6	14.3		20.2	6.9	7.8	2.0	1.9	6.6
11	11.6	14.7	16.6	15.6			20.2	7.6	7.4	1.5	2.5	6.4
12	11.6	14.7	14.2	15.1	15.4	19.0		8.7	7.3	2.3	3.0	9.0
13	11.6	14.9	15.6	14.9	15.1	18.6		8.5	6.9	2.6	4.0	9.7
14	12.2	15.1	15.3	14.7	15.3	22.4		8.4	6.9	2.7	4.5	10.8
15	13.1	15.1	16.0	14.7	15.8	24.4		8.5	6.8	2.7	4.5	9.0
16	13.8	15.1	15.8	14.3	15.8	24.0		8.1	6.6	1.9	3.0	8.2
17	13.3	15.1	16.0	14.2	16.0			7.8	6.6	1.4	2.1	7.4
18	12.9	15.1	16.2	14.2	16.2		14.5	7.6	6.9	0.9	2.5	7.1
19	12.9	14.5	16.0	14.2	14.5	16.6	14.3	7.1	6.2	1.1	1.9	7.0
20	12.9	15.6	16.4	14.2	14.9	18.4	14.2	7.0	6.2	1.4	2.1	6.9
21	12.9	15.3	16.4	13.8	15.3	17.0	14.5	7.1	5.5	2.8	3.0	6.6
22	12.9	14.3	16.4	14.2	16.0	15.6	14.7	8.5	5.3	3.7	2.5	5.4
23	12.8	15.4	16.4	14.7	15.8	16.8	14.5	7.1	3.5	3.3	2.5	4.8
24	12.8	15.4	16.0	14.7	15.8	16.2	14.2	7.3	4.7	3.7	4.5	4.2
25	12.9	13.8	15.3	14.7	13.8	16.6	12.1	7.3	4.2	3.4	5.6	4.4
26	12.9	15.4	14.3	15.1	13.8	18.2	9.7	6.9	4.3	3.6	6.2	4.7
27	13.6	15.4	14.5	15.3	13.8	17.6	9.7	7.0	3.6	3.6	5.0	5.0
28	14.0	13.8	14.5	15.3	13.8	21.1	10.2		3.4	3.5	6.6	4.7
29	13.8	14.7	14.5			21.3	10.5		3.6	3.2	7.0	4.8
30	13.8	16.8	14.5			20.9	10.6		3.4	3.2	6.6	4.0
31	13.8		14.5			20.6				2.5	6.4	

Niobrara River at Agate. Nebraska, Station 06454100												
	Discharge, Cubic Feet per Second, Water Year October 2002 through September 2003											
	Daily Mean Values											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	4.0	10.9		12.1		14.7		11.3	6.8	5.3		5.2
2	4.1	10.5		12.1		15.6		11.3	7.8	4.6		4.6
3	4.3	10.5		12.2			17.6	10.6	7.7	4.3		4.2
4	4.5	10.8		12.6			17.6	10.3	8.2	5.0		5.0
5	4.5	11.1		12.9			18.2	10.6	8.1	5.4		5.0
6	4.5	10.8					18.6	10.8	8.2	5.4		
7	4.6	10.8					18.6	10.5	9.3	5.5		
8	5.4	10.8					19.2	12.4	10.0	5.2		
9	4.5	10.8					19.4	12.8	10.0	5.0		
10	4.0	10.8					18.6	12.2	9.3	4.9		
11	4.0	10.6					17.6	12.1	9.0	4.6		15.3
12	4.0	10.5				18.2	17.2	13.8	8.7	4.9		11.3
13	4.5	10.5				18.6	16.6	14.2	8.5	4.5		8.5
14	4.0	10.5			15.6	18.6	16.0	13.6	8.5	4.3		7.8
15	4.3	10.5			16.0	18.6	14.7	12.9	8.4	4.1		7.7
16	4.5				16.0	18.4	14.2	12.4	7.8	3.7		7.6
17	4.5				15.8	18.6	13.8	11.4	7.6	3.9		7.4
18	4.6		13.6		15.4	20.6	13.6	11.8	8.0	3.7		7.7
19	4.6		10.8		15.4	21.1	13.3	11.3	8.1	4.3		7.8
20	4.7		10.8		15.4	19.6	13.1	11.3	8.0	4.0		7.8
21	4.9		12.1		15.4	19.4	13.1	10.9	7.6	3.4		7.6
22	5.0		12.6		15.3	18.6	15.3	10.3	7.8	3.0		7.3
23	5.3		11.3			17.6		10.2	8.2	3.6		7.0
24	5.5		10.0			17.6	16.0	10.2	7.1	2.8		6.9
25	5.8		10.2			17.2	14.7	10.6	6.8	3.0	4.0	7.0
26	5.6		10.3			17.0	12.4	9.7	6.1		3.9	8.0
27	5.8		10.5			18.6	11.1	7.6	5.6		3.6	7.8
28	5.9		10.6			18.6	10.6	6.9	5.4		3.3	7.3
29	6.0		11.6			17.6	10.2	6.9	5.5		3.3	7.0
30	5.6		11.6			18.6	10.3	6.5	5.6		4.5	7.1
31	7.6		11.9					6.5			5.0	

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 2003 through September 2004

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	7.8	7.4							7.30			
2	8.1	8.5										
3	8.0											
4	7.7											
5	7.6											
6	7.6											
7	7.6											
8	7.6											
9	7.6											
10	7.6								6.9			
11	7.6								6.6			
12	7.7							7.1	6.2			
13	7.7							7.6	5.9			
14	7.8							7.6	5.6			
15	8.0							7.3	4.5			
16	8.1							7.3	4.5			
17	8.1							7.3	5.0			
18	8.1							8.4	5.0			
19	8.1							9.3	5.6			
20	8.1							8.2	6.2			
21	8.1							7.8				
22	8.1							8.2				
23	8.1							8.7				
24	8.1							8.8				
25	8.4							8.1				
26	8.5							7.0				
27	8.5							6.9				
28	8.2							6.9				
29	5.6							6.9				
30	5.3							6.8				
31	5.9							6.6				

Rating Table
and
Rating Curves

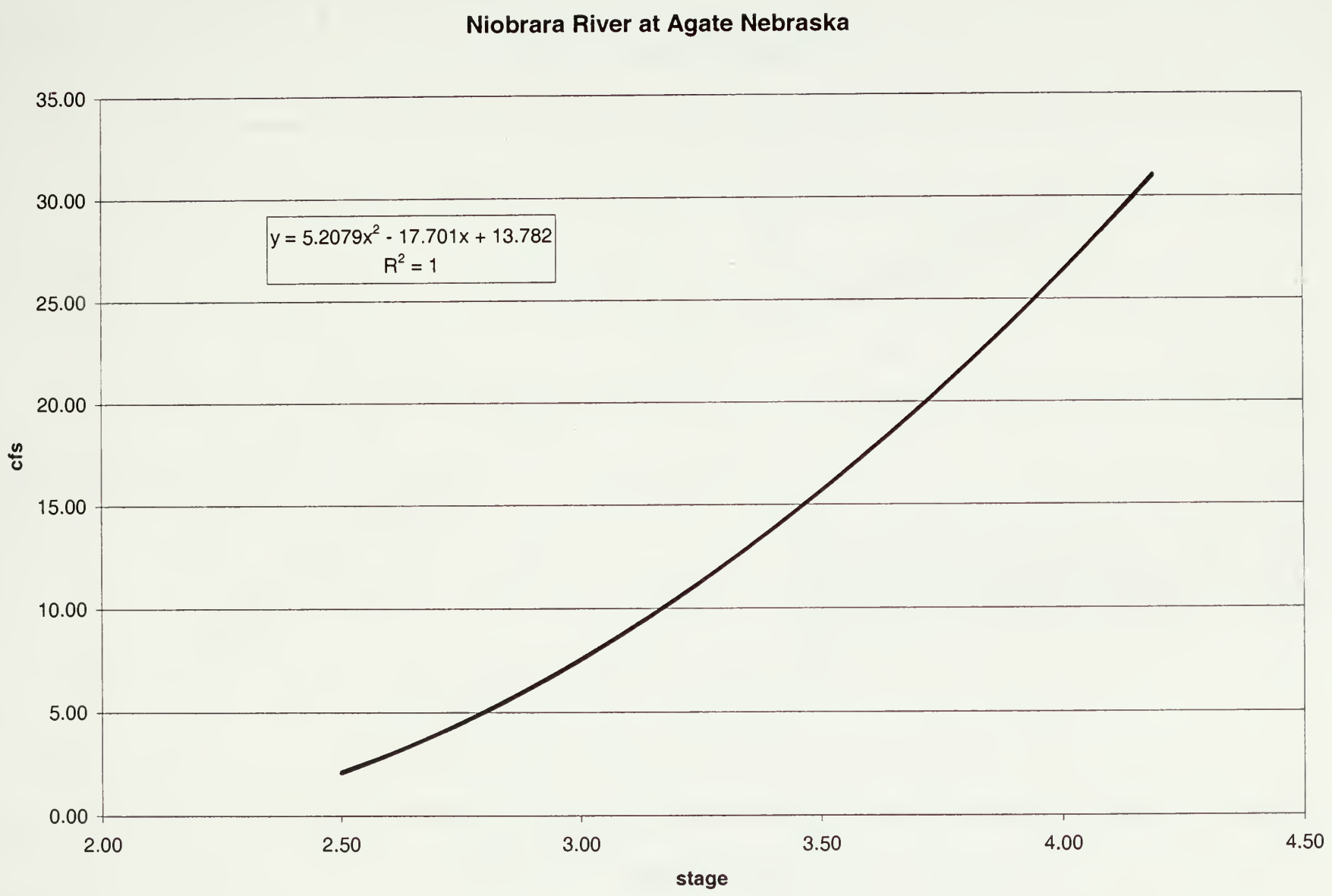
06454100
NIOBRARA RIVER AT AGATE, NEBR.
OFFSET: 2.00

EXPANDED RATING TABLE
DATE PROCESSED: 11-23-1994 @ 14:42 BY DEHITCH

TYPE: LOG
DD: 2 TYPE: 001 RATING NO: 8.00
START DATE/TIME: 10-01-86 (0015)

BASED ON _____ DISCHARGE MEASUREMENTS, NOS _____, AND _____, AND IS _____ WELL DEFINED BETWEEN _____ AND _____ CFS
COMP BY _____ DATE _____ CHK. BY _____ DATE _____

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
2.50	2.150*	2.228	2.308	2.389	2.471	2.554	2.638	2.724	2.811	2.899	.839
2.60	2.989	3.079	3.171	3.264	3.358	3.454	3.550	3.648	3.747	3.847	.959
2.70	3.948	4.051	4.154	4.259	4.365	4.472	4.581	4.690	4.801	4.912	1.077
2.80	5.025	5.139	5.255	5.371	5.488	5.607	5.727	5.847	5.969	6.093	1.192
2.90	6.217	6.342	6.469	6.596	6.725	6.855	6.985	7.117	7.251	7.385	1.303
3.00	7.520	7.656	7.794	7.933	8.072	8.213	8.355	8.498	8.642	8.787	1.413
3.10	8.933	9.080	9.228	9.378	9.528	9.680	9.832	9.986	10.14	10.30	1.517
3.20	10.45	10.61	10.77	10.93	11.09	11.25	11.42	11.58	11.75	11.91	1.630
3.30	12.08	12.25	12.42	12.59	12.76	12.93	13.11	13.28	13.46	13.63	1.730
3.40	13.81	13.99	14.17	14.35	14.53	14.71	14.90	15.08	15.27	15.45	1.830
3.50	15.64	15.83	16.02	16.21	16.40	16.60	16.79	16.99	17.18	17.38	1.940
3.60	17.58	17.78	17.98	18.18	18.38	18.58	18.79	18.99	19.20	19.40	2.030
3.70	19.61	19.82	20.03	20.24	20.45	20.67	20.88	21.09	21.31	21.53	2.130
3.80	21.74	21.96	22.18	22.40	22.63	22.85	23.07	23.30	23.52	23.75	2.240
3.90	23.98	24.20	24.43	24.66	24.89	25.13	25.36	25.59	25.83	26.07	2.320
4.00	26.30	26.54	26.78	27.02	27.26	27.50	27.75	27.99	28.23	28.48	2.430
4.10	28.73	28.97	29.22	29.47	29.72	29.97	30.23	30.48	30.73	30.99	2.510
4.20	31.24	31.50	31.76	32.02	32.28	32.54	32.80	33.06	33.33	33.59	2.620
4.30	33.86	34.12	34.39	34.66	34.93	35.20	35.47	35.74	36.01	36.29	2.700
4.40	36.56	36.84	37.11	37.39	37.67	37.95	38.23	38.51	38.79	39.08	2.800
4.50	39.36	39.65	39.93	40.22	40.51	40.79	41.08	41.37	41.67	41.96	2.890
4.60	42.25	42.54	42.84	43.14	43.43	43.73	44.03	44.33	44.63	44.93	2.980
4.70	45.23	45.53	45.84	46.14	46.45	46.76	47.06	47.37	47.68	47.99	3.070
4.80	48.30	48.61	48.93	49.24	49.56	49.87	50.19	50.51	50.82	51.14	3.160
4.90	51.46	51.78	52.11	52.43	52.75	53.08	53.40	53.73	54.06	54.38	3.250
5.00	54.71	55.04	55.37	55.71	56.04	56.37	56.71	57.04	57.38	57.71	3.340
5.10	58.05	58.39	58.73	59.07	59.41	59.75	60.10	60.44	60.79	61.13	3.430
5.20	61.48	61.83	62.18	62.52	62.87	63.23	63.58	63.93	64.28	64.64	3.510
5.30	64.99	65.35	65.71	66.06	66.42	66.78	67.14	67.51	67.87	68.23	3.600
5.40	68.59	68.96	69.33	69.69	70.06	70.43	70.80	71.17	71.54	71.91	3.690
5.50	72.28	72.66	73.03	73.41	73.78	74.16	74.54	74.91	75.29	75.67	3.780
5.60	76.06	76.44	76.82	77.20	77.59	77.97	78.36	78.75	79.14	79.52	3.850
5.70	79.91	80.31	80.70	81.09	81.48	81.88	82.27	82.67	83.06	83.46	3.950
5.80	83.86	84.26	84.66	85.06	85.46	85.86	86.27	86.67	87.07	87.48	4.030
5.90	87.89	88.29	88.70	89.11	89.52	89.93	90.34	90.76	91.17	91.58	4.110*
6.00	92.00*										


Niobrara River at Agate Nebraska
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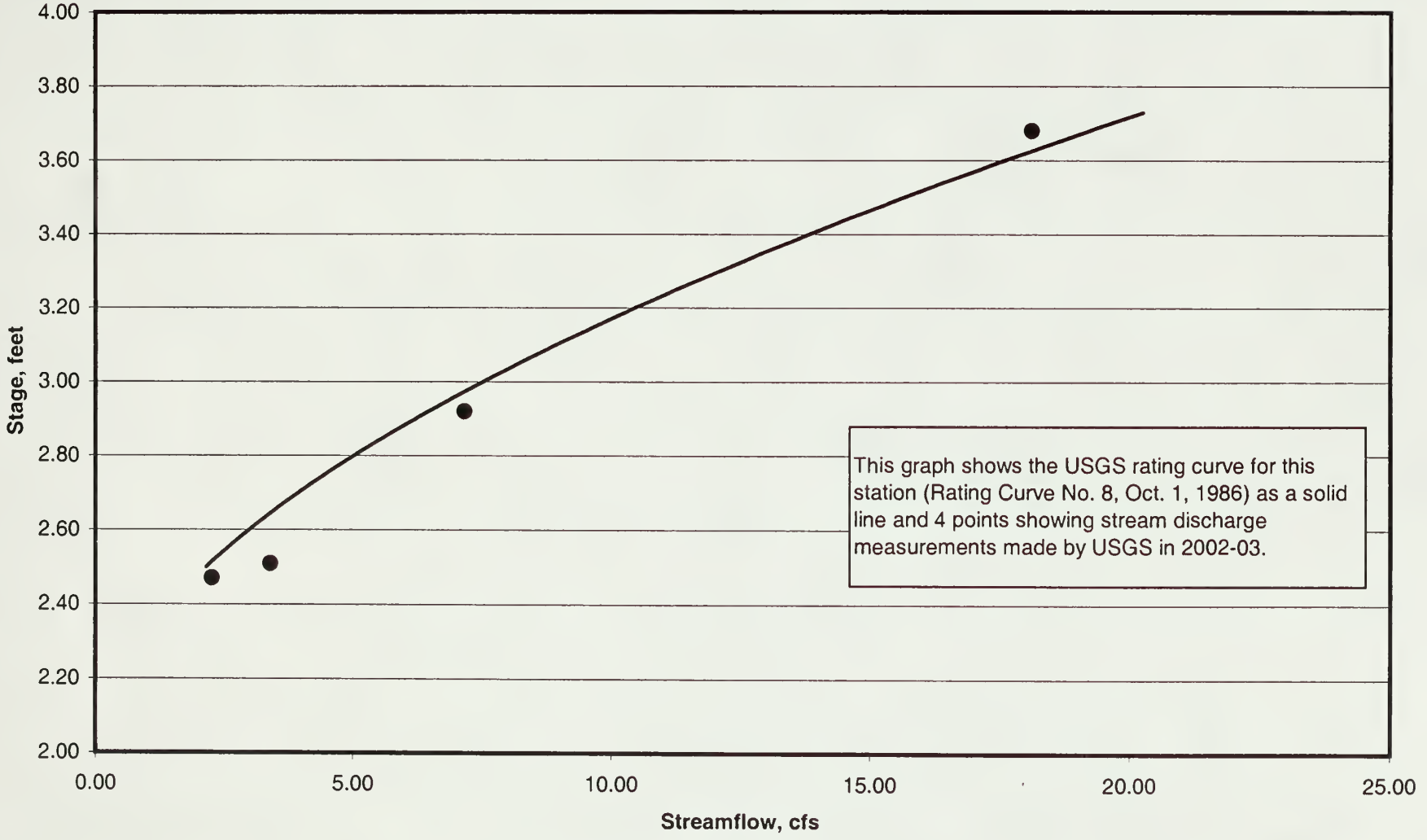
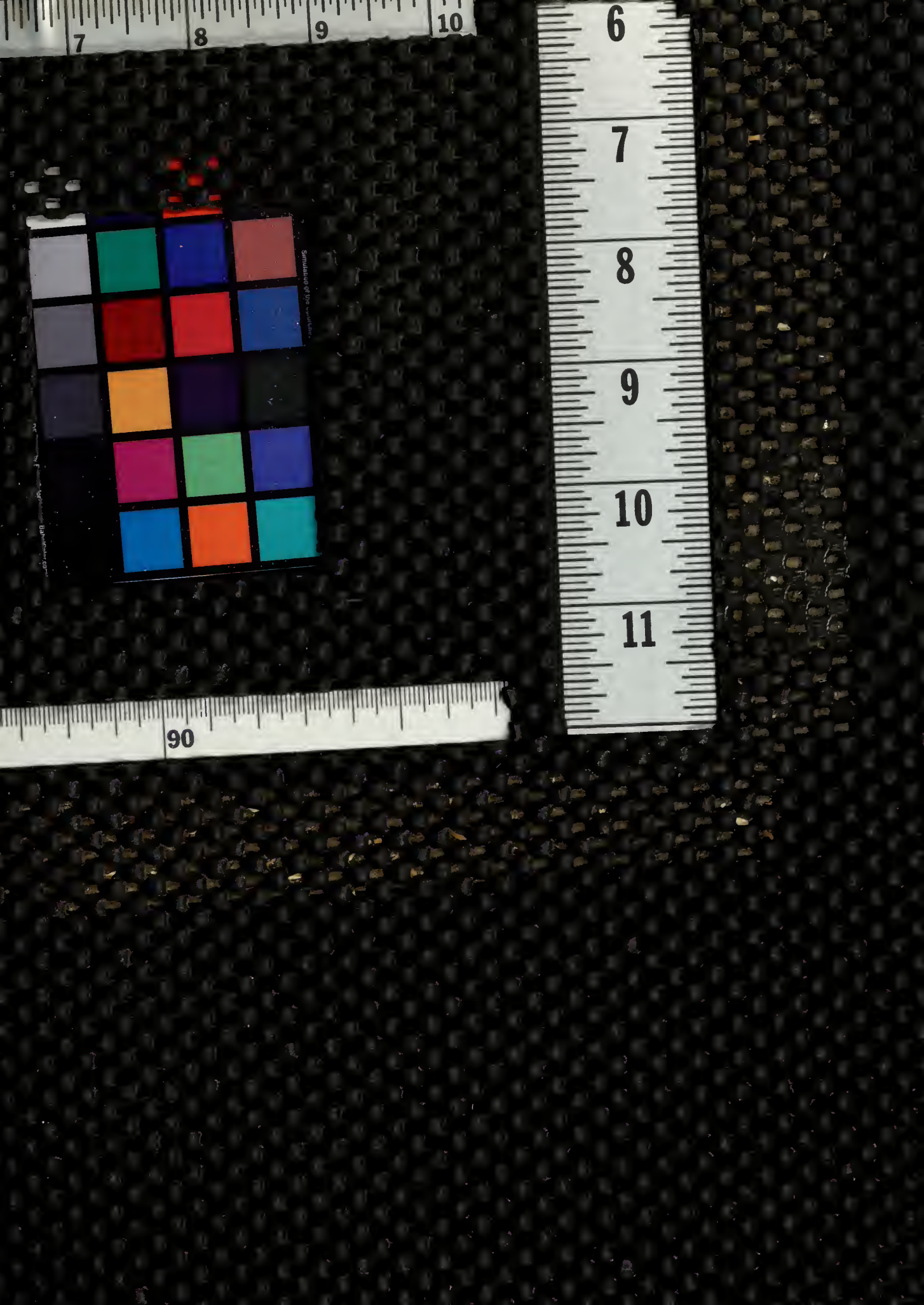
R² = 1
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
cfs
2.00
2.50
3.00
3.50
4.00
4.50
stage

Niobrara River at Agate, Nebraska
USGS Station 06454100



As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-39 February 2005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